Technical **Bulletin** TB96-1

Agricultural Experiment Station

Department of Soil and Crop Sciences

March 1996

Sustainable Dryland Agroecosystem Management

G.A. Peterson
D.G. Westfall
L. Sherrod
R. Kolberg
D. Poss

Colorado State University

Colorado State University does not discriminate on the basis of race, age, color, religion, national origin, gender, disability, sexual orientation, veteran status or disability. The University complies with the Civil Rights Act of 1964, related Executive Orders 11246 and 11375, Title IX of the Education Amendments Act of 1972, Sections 503 and 504 of the Rehabilitation Act of 1973, Section 402 of the Vietnam Era Veterans' Readjustment Act of 1974, the Age Discrimination in Employment Act of 1967, as amended, Americans with Disabilities Act of 1990, the Civil Rights Act of 1991, and all civil rights laws of the State of Colorado. Accordingly, equal opportunity of employment and admission shall be extended to all persons, and the University shall promote equal opportunity and treatment through a positive and continuing affirmative action program. The Office of Equal Opportunity is located in 101 Student Services. In order to assist Colorado State University in meeting its affirmative action responsibilities, ethnic minorities, women, and other protected class members are encouraged to apply and to so identify themselves.

1996

SUSTAINABLE DRYLAND AGROECOSYSTEM MANAGEMENT

G.A. Peterson[2], D.G. Westfa11[2], L. Sherrod[3],
R. Kolberg[2], and D. Poss[2]

A Cooperative Project

of the
Colorado Agricultural Experiment Station
Department of Soil and Crop Sciences
Colorado State University
Fort Collins, Colorado

and the

USDA - Agriculture Research Service
Natural Resources Research Center
Great Plains Systems Research Unit
Fort Collins, Colorado

'Funding is provided by: Colorado Agricultural Experiment Station, USDA-ARS; High Plains Regional Climate Center.

[2]Professors of Soil and Crop Sciences and Research Associates, Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO 80523

[3]USDA-ARS Technician - Great Plains Systems Research Unit

Table of Content

List of Tables

RESEARCH APPLICATION SUMMARY

We established the Dryland Agroecosystem Project in the fall of 1985 and the frost crop year was 1986. Grain yields, stover yields, crop residue amounts, soil water measurements, and crop nutrient content are reported annually in technical bulletins. This summary updates our findings for the 10 year period.

The wheat-corn-fallow (3 year) and wheat-corn-millet-fallow (4 year) rotations have increased average annualized grain production by 72% compared to wheat-fallow. Yields are annualized to account for the nonproductive fallow year in rotation comparisons. Economic analyses show this to be a 25-40°/0 increase in net annual income for the three year rotation in northeastern Colorado. However, in southeastern Colorado the economic outcome has not been as favorable. The three year wheat-sorghum-fallow rotation, using stubble mulch tillage in the fallow prior to wheat planting, netted about the same amount of money as reduced till wheat-fallow. New herbicide programs with fewer expensive residual materials are being tested and have showed some promise. No-till management allows more water storage than conventional tillage, but it also costs more to control the weeds with herbicides used at labeled rates than by tillage. By inserting summer crops like corn, grain sorghum, and annual forages into the rotation the additional water stored is converted to additional production that results in more profit than with wheat-fallow.

Annual yield fluctuations concern growers because they cannot tolerate wide swings in gross income. Stable yields translate into stable income levels in their operations. Figure 1 provides a summary of 10 years of yield history for wheat, corn, sorghum, and proso millet at our three study locations. Wheat has been grown all 10 years at all sites, corn every year at Sterling, and sorghum every year at Walsh. Other crops have been grown for shorter periods of time. Complete data sets for each crop are available in previously published bulletins (See reference section).

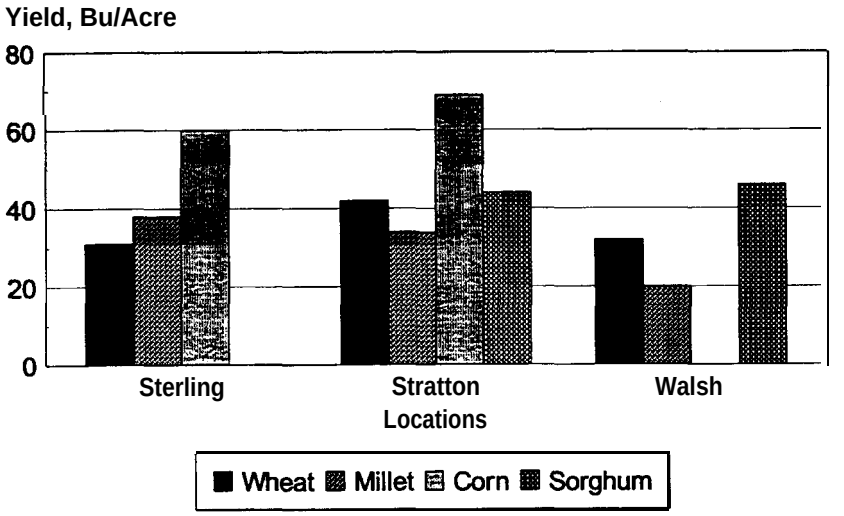

Figure 1. Grain yields averaged over soil positions and 10 years of production for each location.

We included all years where yield losses occurred due to hail, early and late freezes, insect pests, and herbicidal carryover. Fluctuations in corn and sorghum yields are of most interest because they represent the highest input crops. Corn yields have averaged 60 bu/A (Ranging from 14 to 97 bu/A) at Sterling and 69 bu/A (Ranging from 37 to 95 bu/A) at Stratton. These averages include the disastrous yields recorded in 1994. Grain sorghum was produced at Stratton for 4 years and yielded " an average of 44 bu/A (Ranging from 20 to 63 bu/A), but corn has averaged 69 bu/A for the past 6 years, making it a better choice for this environment. At Walsh grain sorghum yields have averaged . 46 bu/A (Ranging from 27 to 74 bu/A), including the results from the very dry 1995 season.

Producers in northeastern Colorado have been adopting the more intensive cropping systems at an increasing rate since 1990. Since corn is one of the principle crops used in more intensive systems, its acreage can be used as an index of adoption rate by producers (See table below). Area planted to dryland corn has increased from about 20,000 acres per year in years previous to 1990 to over 95,000 acres in 1995. Data for sunflower and proso millet in similar rotations are not available for evaluation, but individual producers report larger acreages of these crops as well.

Dryland Corn Acreage in Eight Northeastern Colorado Counties from 1971 to 19951.

YEAR	ACRES
1971-1988	21,200
1989	27,000
1990	26,000
1991	32,500
1992	48,500
1993	79,000
1994	92,000
1995	95,000

[1]Data from Colorado Agricultural Statistics (Adams, Kit Carson, Logan, Morgan, Phillips, Sedgewick, Washington, Yuma)

Producers wishing to get started in dryland rotation farming may consult bulletins published in previous years and/or the publication by Croissant, et al. (1992).

CONCURRENT RESEARCH PROJECTS

Wheat - Corn Rotation at Sterling: {Established in fall 1993}

Objective:

Maximize time in crop and minimize weed control costs between crops.

Procedure:

i) Roundup, Atrazine, and Command applied after winter wheat harvest.
ii) Corn planted into the wheat stubble the following May with an Atrazine+ Prowl weed control program. If needed Banvel is used for kochia control.
iii) Corn is harvested in late September and wheat is planted the same day, directly into the corn stalks.

Results:

i) Corn yields in 1994 only averaged 9 bu/A because of the drought in July and August.
ii) There was very little stored water at wheat planting in 1994 because of the dry summer Therefore, wheat yields in 1995 averaged 32 bu/A over the three soil positions compared to an average of 26 bu/A for wheat in the WCF and WCSF rotations. .
iii) A herbicide mishap prevented corn production in 1995.

Expectations:

Since wheat yield is most dependent on May and June rainfall, wheat planted following corn should yield well if plants can be established in the dry soil following corn harvest. Corn yields would be expected to be similar to those obtained in other rotations.

Experiment Managers:

G.A. Peterson, G. Lindstrom, and D.G. Westfall

Triticale-Corn-Hay Millet Rotation at Sterling: {Established in fall 1993}

Objective:

Maximize time in crop, provide both a cash crop (corn) and forage crops for a mixed livestock-grain farm. Land preparation costs would also be minimized.

Procedure:

i) Winter triticale is planted in September into the hay millet stubble.
ii) Harvest winter triticale for forage in June before heading, leaving a 8-10 inch stubble. Roundup, Atrazine, and Command applied after harvest.
iii) Corn planted into the triticale stubble the following May with an Atrazine + Prowl weed control program. If needed Banvel used for kochia control.
iv) Corn is harvested in late September.
v) Hay millet is planted into corn stalks the following May and is harvested in July, leaving a 4-6 inch stubble. Weeds controlled with Roundup if necessary.

Results:

i) Triticale yields:

	1994				1995			
	Summit	Sideslope	Toeslope	Average	Summit	Sideslope	Toeslope	Average
Production	T/Acre							
Total[1]	2.6	2.2	3.5	2.8	4.6	4.3	3.7	4.2
Harvested[2]	1.5	1.2	2.0	1.6	3.8	3.6	2.9	3.4

[1] = Harvested at ground level; [2] = Harvested leaving 10" stubble

ii) Corn yields in 1994 only averaged <3 bu/A because of the drought in July and August, and averaged 22 bu/A in 1995.

iii) Hay millet yields were non-harvestable in both 1994 and 1995. The dry summers were not conducive to hay millet production.

Expectations:

Winter triticale seems to be a well adapted cool season forage crop. Corn following triticale should be equivalent to corn after wheat, which has a good record at this site over a ten year period of years. The hay millet, given a more normal spring moisture pattern, should 1-2 T/A of forage.

Experiment Managers:

G.A. Peterson, G. Lindstrom, and D.G. Westfall

Wheat-Corn-Pea Rotation at Sterling and Stratton: {Experiment established in fall 1994}

Objective:

Grow winter or spring peas, legumes, after corn harvest and before wheat in the wheat-corn-fallow rotation to evaluate amount of cover produced, water requirement potential of peas as a forage, and the N contribution from the legumes to subsequent crops in the rotation.

Procedure:

i) Austrian Winter Pea planted no-till in fall after corn harvest. Spring peas planted no-till in March after corn harvest.

ii) Late June to early July peas are harvested. Treatments are: 100% vegetation removed; 50% removed; 0% removed; and a control with no peas. Soil water content is measured monthly in the peas. After harvest remaining peas are killed with Roundup to stop water use.

iii) Winter wheat is planted in September. Herbicides used same as the wheat-corn-fallow rotation.

iv) Corn is planted in wheat stubble each spring. Herbicides used same as the wheat-corn-fallow rotation.

Results:

i) Austrian winter peas at Stratton yielded 3500 lbs/acre and spring peas yielded 1380 lbs/acre. At Sterling no pea yields were measured because of erratic stands and weed infestations. Total nitrogen content of the above ground material was 40 and 118 lbs/acre for spring and winter peas, respectively. Root N content averaged 16 lbs/acre for both spring and winter peas.

ii) Wheat yields averaged 32 bu/A at Sterling and 45 bu/A at Stratton. Corn yields averaged 19 bu/A at Sterling and 28 bu/a at Stratton.

Expectations:

Soil water measurements are being made to determine how much water is used by the peas and how that might affect subsequent winter wheat yields. Data from the literature would indicate there should be little effect on wheat yield because pea water use is minimal, and water storage from pea harvest to wheat planting should be adequate to establish good winter wheat stands in the fall.

Experiment Managers:

David Poss, G.A. Peterson and D.G. Westfall

Phosphorus Soil Test Calibration Using Landscape Variability at Sterling and Stratton:
{Experiment established fall 1994}

Objective:

Develop a methodology of soil test calibration using spatial variability found in landscapes, and determine variability in P soil tests over landscapes.

Procedure:

Transects were defined over three landscapes ranging in length from 230 to 1420 feet. Soil samples were collected at 20 foot intervals from three depths: 0-4", 4-8" and 8- 12". Five rates of phosphate ($P_2 0_5$) (O, 10, 20, 30, and 40 lbs/A) were band-applied in parallel at winter wheat planting time. Wheat was harvested in 20 foot intervals along each transect. Soil samples were analyzed for available P, organic matter, total nitrogen, pH, and soil texture. Regression techniques were used to relate soil tests to wheat yields.

Results:

The late season frost at both Sterling and Stratton affected the wheat yield response to P fertilizer. For example, on low soil test areas the higher rates of P fertilizer advanced the wheat maturity and the frost damaged the plants more than the wheat in the control strip where no P was applied. This caused yields to best on non-P fertilized strips and made it impossible to establish meaningful relationships between soil tests and P fertilization effects. Soil test P levels varied from 4 ppm to 40 ppm over the landscape. Spatial variability in sol characteristics is large, and accounts for much of the variability in yields farmers observe over landscapes.

Expectations:

The proposed methodology would speed the soil test calibration process and make it more economical to conduct. It makes it possible to develop regional fertilizer recommendations that relate directly to variable rate technology and should be more accurate than those obtained by traditional experiments at many unrelated sites. This study will allow us to determine the potential use of variable rate fertilizer technology in dryland farming.

Experiment Managers:

Rodrigo Ortega, D.G. Westfall and G.A. Peterson

Beneficial Insects, Predators of Russian Wheat Aphid, Experiment: {Experiment established fall 1994}

Objective:

Determine if having summer crops like corn, sunflower, and hay millet in close proximity to wheat will allow insect predators of Russian Wheat Aphid to maintain their population levels and thus be present at winter wheat planting in the fall.

Procedure:

Corn, sunflower and hay millet are planted in small plots near winter wheat plots where Russian Wheat Aphid predators have been released. Insect populations are monitored periodically over the summer and fall.

Results:

To date the establishment of significant populations of the predator insects has not been very successful, and it has been impossible to determine if the summer crops aid in maintaining their populations.

Project Managers: Meg Donohue, Frank Peairs, Tom Holtzer, D.G. Westfall, G.A. Peterson

Fluid Systems for Dryland Agriculture: {Established in 1993 at Sterling and Stratton}

Objectives:

Develop fluid systems where fertilizers and herbicides can be applied together.

Procedures:

Wheat-fallow rotation fluid systems

Varying rates of N fertilizer are tank mixed or applied separately in the fall or spring with labeled rates of Atrazine, Command, Roundup, Banvel or 2,4-D. Nitrogen rates are 0, 30, 60, and 90 lbs N/A.

Wheat-corn-fallow rotation fluid systems

Wheat fluid systems same as outlined above.

For corn, varying rates of N fertilizer are tank mixed or applied separately in the spring or summer with labeled rates of Atrazine, Command, Prowl, or Banvel. Nitrogen rates are 0, 35, 70, and 105 lbs N/A.

Results:

The summer drought in 1994 prevented corn harvest at Sterling in 1994. August precipitation in August, 1995, was 12% and 54% of normal at Sterling and Stratton, and coupled with the early killing frost in September, resulted in average corn yields of 31 and 37 bu/A, respectively. Wheat yields averaged 26 and 43 bu/A at Sterling and Stratton, respectively, being limited by the late spring frost, particularly at Sterling. No definite fluid system effects have emerged. However, better weed control occurred as N rate increased.

Expectations:

It was hoped that system effects would emerge with time. Synergistic effects between N fertilizers and herbicides are anticipated. This appears to be occurring with the interaction between N rate and weed control. However, future funding for the project is in question, it may have to terminated before its 6-year life is completed.

Project Managers: R. L. Kolberg, D. G. Westfall, and G. A. Peterson

INTRODUCTION

Colorado agriculture is highly dependent on precipitation as both snow and rainfall. Dryland acreage exceeds irrigated acreage by more than two fold, and each unit of precipitation is critical to production. At Akron each additional inch (25 mm) of water above the initial yield threshold translates into 4.5 bu/A of wheat (12 kg/ha/mm), consequently profit is highly related to water conservation (Greb et al. 1974).

A research project was established in 1985 to address efficient water use under dryland conditions in Eastern Colorado. A more comprehensive justification for its initiation has been reported previously (Peterson, et al., 1988). The general objective of the project is to identity dryland crop and soil management systems that will maximize water use efficiency of the total annual precipitation.

Specific objectives are to:

1. Determine if cropping sequences with fewer and/or shorter summer fallow periods are feasible.
2. Quantify the relationship of climate (precipitation and evaporative demand), soil type and cropping sequences that involve fewer and/or shorter fallow periods.
3. Quantify the effects of long-term use of no-till management systems on soil structural stability, micro-organisms and faunal populations of the soil and the organic C, N, and P content of the soil, all in conjunction with various crop sequences.
4. Identify cropping or management systems that will minimize soil erosion by crop residue maintenance.
5. Develop a data base across climatic zones that will allow economic assessment of entire management systems.

Peterson, et al.(1988), document details of the project in regard to the “start up” period and data from the 1986-87 crop year. Results from the 1988-1994 crop years were reported by Peterson, et al., 1989, 1990, 1991, 1992, 1993, 1994 and 1995. As in previous bulletins, only annual results are presented. Cropping system research is highly time and weather dependent, and therefore we do not draw major conclusions on an annual basis. Other publications, such as Wood, et al. (1990), Croissant, et al. (1992), and Peterson, et al. (1993a & 1993b) summarize and draw conclusions based on a combination of years.

MATERIALS AND METHODS

We are studying interactions of climate, soils and cropping systems. Three sites, located near Sterling, Stratton, and Walsh, were chosen in Eastern Colorado that represent a gradient in potential evapotranspiration (PET) (Fig. 1). All sites have long-term precipitation averages of approximately 16-17 inches (400-425 mm), but increase in PET from north to south. Open pan evaporation, an index of PET for the cropping season, ranges from 40 inches (1,050 mm) in the north to 75 inches (1,900 mm) in the south. Elevations are 4400(1341 m), 4380(1335 m), and 3720 (1134 m) feet above sea level at Sterling, Stratton, and Walsh, respectively.

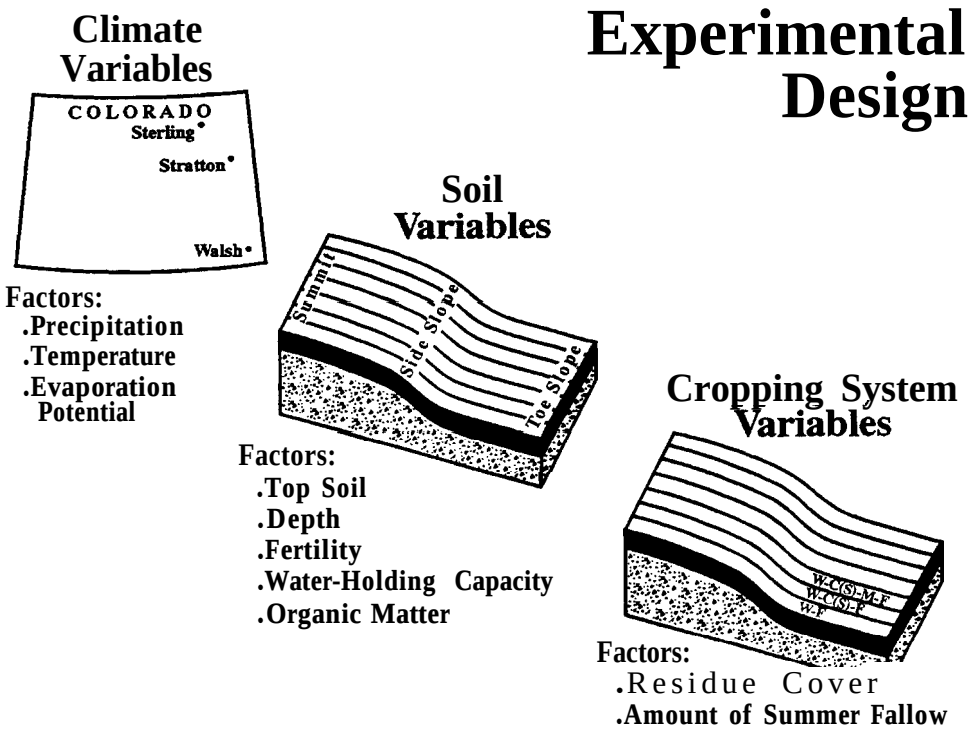

Figure 2. Experimental locations on a climatic gradient, soil variables by slope position, and cropping systems over soil positions.

Each site was selected to represent a catenary sequence of soils common to the geographic area. All fields chosen had been cultivated for more than 50 years. The cropping system during this time primarily had been dryland wheat-fallow with some inclusion of grain sorghum at Walsh and corn at Sterling. We placed cropping system treatments over the soil sequence at each site (Fig. 1) and they are identified in Table 1. Each system is managed with no-till techniques, and herbicide programs are reported in Appendix Tables 1,2 and 3. We are testing two of the cropping systems, wheat-fallow and wheat-corn or sorghum-fallow using conventional stubble mulch tillage at Sterling and Walsh. Complete details on measurements being made and reasons for treatment choices are given by Peterson, et al.(1988). Wheat, TAM 107, **was** planted at 60 lbs/A (67 kg/ha) on 20,26, and 26 September 1994 at Sterling, Stratton, and Walsh, respectively. Corn, Pioneer 3732, was planted on 19 and 16 May 1995 at 17,100 seeds/A (42,240 seeds/ha) at Sterling and Stratton, respectively. Corn, Pioneer 3655, was planted in the continuous row crop treatment(formerly Continuous Sorghum) on 18 April 1995 at Walsh. Corn was replanted at Walsh on 16 May 1995. Sorghum, Cargill 607E, was planted at Walsh on 8 June 1994 at a seeding rates of 43,000 seeds/A (106,210 seeds/ha) in the WSF and WSSF treatments. Sunflower, Northrup King 258, was planted at a rate of 17000 seeds/A (41990seeds/ha) on 16 May 1995 at Walsh. Sunflower, Triumph 505C, was planted on 13 and 14 June 1995 at Sterling and Stratton, respectively. The sunflower crop failed at the two northern sites and we replanted these treatments with forage sorghum, Canex, at a rate of 10 lbs/A on 12 and 13 July at Sterling and Stratton, respectively.

Table 1. Management systems for each site in 1995.

Site	Rotations
Sterling	1) Wheat-Fallow (WF) 2) Wheat-Corn-Fallow (WCF) 3) Wheat-Corn-Millet-Fallow (WCMF) 4) Opportunity Cropping* 5) Perennial Grass
Stratton	1) Wheat-Fallow (WF) 2) Wheat-Corn-Fallow (WCF) 3) Wheat-Corn-Millet-Fallow (WCMF) 4) Opportunity Cropping" 5) Perennial Grass
Walsh	1) Wheat-Fallow (WF) 2) Wheat-Sorghum-Fallow (WSF) 3) Wheat-Sorghum-Sorghum-Fallow (WSSF) 4) Continuous Row Crop (Alternate corn & sorghum) 5) Opportunity Cropping* 6) Perennial Grass

*Opportunity cropping is designed to be continuous cropping without fallow, but not monoculture.

Opportunity Cropping History

Year	Site		
	Sterling	Stratton	Walsh
1985	Wheat	Fallow	Sorghum
1986	Wheat	Wheat	Sorghum
1987	Corn	Sorghum	Millet
1988	Corn	Sorghum	Sudex
1989	Attempted Hay Millet	Attempted Hay Millet	Sorghum
1990	Wheat	Wheat	Attempted Sunflower
1991	Corn	Corn	Wheat
1992	Hay Millet	Hay Millet	Corn
1993	Corn	Corn	Fallow
1994	Sunflower	Sunflower	Wheat
1995	Wheat	Wheat	Wheat

Nitrogen fertilizer is applied annually in accordance with the NO_3-N content of the soil profile (0-6 ft or 0-180 cm) before planting, and expected yield on each soil position at each site. Therefore, N rate changes by year, crop grown, and soil position. Fertilizer N rates applied for the 1995 crops are shown in Table 2. Nitrogen fertilizer for wheat, corn, and sunflower was dribbled on the soil surface over the row at planting time at Sterling and Stratton. Nitrogen on wheat at Walsh was spring topdressed and N was sidedressed on corn and sorghum. We made all N applications as 32-0-0 solution.

We applied P (10-34-0) at planting of all crops near the seed. Phosphorus was applied on one-half of each corn and proso millet plot over all soils, but applied to the entire plot in the case of wheat. The rate of P is determined by the lowest soil test on the catena which is usually found on the sideslope position. This rate has been 8.5 lbs/A (9.5 kg/ha) of P at each site each year thus far. We changed the P fertilization treatment for wheat in fall 1992, so that the half plot that had never received P fertilizer in previous years was treated when planted to wheat for the 1993 crop. Other crops in the rotation only receive P on the half plot designated as NP. Zinc (0.9 lbs/A or 1 kg/ha) was banded near the seed at corn planting at Sterling and Stratton to correct a deficiency identified by soil test.

We measured soil water with the neutron scatter technique. Aluminum access tubes were installed, two per soil position, in each treatment at each site in 1988. These tubes are not removed for any field operation and remain in the exact positions year to year. Precautions are taken to prevent soil compaction around each tube. By not moving the tubes over years we get the best possible estimates of soil water use in each rotation. Soil water measurements are made on all soils and rotations at planting and harvest of each crop, which also represents the beginning and end of non-crop or fallow periods. We also measured soil water hi-weekly throughout the summer in each crop on the summit and toeslope soil positions.

RESULTS AND DISCUSSION

Climatic Data

The precipitation pattern at all sites was skewed in 1995 (Table 3a). Amounts in the first six months of 1995 were above the long-term averages, and the second half amounts were below average. Precipitation in the first half of 1995 exceeded the average by 5.8 in. (147 mm) at Sterling, by 4 in. (102 mm) at Stratton, and by 1 in. at Walsh. Deficits in the second half were 2.4 in. (61 mm) at Sterling, 2.6 in.(66 mm) at Stratton, and 6.8 in. (173 mm) at Walsh. August rainfall at Sterling and Walsh was less than 0.25 in.(6 mm), which was devastating to the corn and sorghum crops. Cold temperatures accompanied the wetter spring conditions, which delayed growth of spring planted crops, but was excellent for wheat. Unfortunately, however, air temperatures, from about 0200 on 10 April until 0800 on 12 April fell below the freezing point at all sites. During this three-day period temperatures were near 18° F for a period of 6 to 8 hours. Figure 2 depicts the hourly temperature pattern for Walsh, which was typical of all sites. Although the wheat heads had not emerged by 10 April, major damage occurred, sterile florets resulted, and wheat grain yields were greatly decreased, especially at Walsh, because the wheat was most advanced at that location.

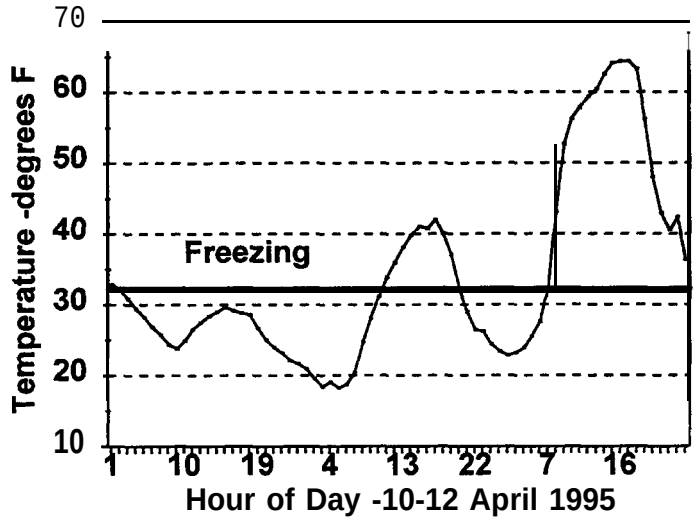

Figure 3. Hourly temperatures at Walsh from midnight on 10 April to midnight on 12 April 1995.

Hail occurred at Stratton in August and severely damaged the corn crop, 30% corn yield loss. The cold spring delayed corn growth, and an earlier than average frost on three consecutive nights, 20-22 September, at Sterling and Stratton further decreased corn grain yield.

Wheat

A severe freeze that occurred between 9 and 12 April decreased wheat yields in 1995. At Sterling yields ranged from 8 to 35 bu/A (520-2380 kg/ha) depending on soil position and rotation(Table 4a & 4b). Although these grain yields were near the 10 year average for the Sterling site (Table 5), the potential for much greater yield obviously was present as evidenced by the large amounts of stover produced. At Walsh, where the wheat crop was most advanced in maturity in early April compared to the other sites, grain yields were less than half the long-term averages (Table 7). Based on more normal grain: stover ratios, the grain yield should have been near 60 bu/A (3200 kg/ha) at Sterling and near 40 bu/A (2100 kg/ha) at Walsh if no frost had occurred. Although the frost also occurred at Stratton, the stage of growth obviously was less vulernable because wheat yields still averaged 43 bu/A (2300 kg/ha) (Tables 4a &4b).

Wheat yields in the WF rotation on all soils at Sterling and on the toeslope soil at Stratton were depressed compared to yields in either WCF or WCSF (Tables 4a &4b). Downy brome, a winter annual grassy weed, was at epidemic levels in the WF rotation in the cases where grain yields were depressed. This weed is always present to some degree in our systems, especially in WF, but climatic conditions allowed it to erupt in 1995. Inmost years the primary flush of downy brome has occurred before wheat seeding and we control it with Roundup. In fall 1994, however, there had been no late August or early September rain to germinate the weed seed before wheat seeding, and this meant we had no opportunity to kill the downy brome prior to seeding. In WCF, WCSF, and Opportunity cropping there is a smaller downy brome seedbank because during the growth cycles of corn and sunflower this weed does not go to seed. Hence

the effects of downy brome on wheat yields was a large problem in 1995 for WF, but not for the other rotations. The toeslope position in WF at Stratton was most affected by the downy brome because the historically good moisture conditions in that soil have left a larger seedbank than on either the summit or sideslope. No yield differences due to rotation were observed at Walsh.

Corn and Sorghum

Corn and sorghum yields were lower than our long-term averages at all sites (Tables 9, 10& 11). This was due in part to below average precipitation, but some herbicidal stunting of the corn at Sterling combined with an earlier than normal killing frost at both Sterling and Stratton also reduced yield (Table 8a & 8b). Corn at Stratton was not stunted, but did receive hail. Toeslope corn yields at Sterling and Stratton were the highest compared to the other soils, as is usually the case (Table 8a & 8b). Phosphorus fertilization had no apparent affect on grain yield on even the lowest soil test positions, sideslopes. Recall that the entire experimental plot now receives P fertilizer when planted to wheat. Data from 1995 would indicate that the carryover of P from the fertilized wheat crop meets the P need for following corn crop. These results, however, may not be conclusive because of the unusual growing season that included the early killing frost.

Sorghum yields at Walsh ranged from 18 to 43 bu/A (Tables 8a & 8b), which is about 70% of the long-term average (Table 11). For the first time in 10 years yields on summit and sideslope soils were equal to those on the toeslope position. Total rainfall for July and August was only 0.14 inches, which is the grain fill period for sorghum (Table 3a). Considering the very low precipitation the grain yields were actually quite good. The yields were possible because of very good water storage in the period from 1994 wheat harvest and sorghum planting in spring 1995. There was an average of 8.5 inches of available water in all soils at planting in the WSF and the WSSF-1 (first year sorghum) rotations, while all soils averaged about 6.0 inches of available water in the WSSF-2 rotation (second year sorghum). In the latter rotation water storage was only possible from sorghum harvest in fall 1994 until planting time in spring 1995. By sorghum harvest there was less than 1 inch of available water remaining in the top 4 feet of soil in any rotation or any soil position (Tables 24,25& 26).

Sorghum responded positively to P application in 1995 on both the summit and sideslope soils in all rotations (Tables 8a & 8b). The yield increases ranged from 2 to 9 bu/A. Even though soil P tests are low on these two soils, we have not always observed a positive yield response to P fertilization. In fact in some years yields have decreased with addition of P fertilizer. Perhaps in a stress year like 1995, the P promoted enough extra root growth that soil water was used more efficiently in P treated plots. Unfortunately we do not have soil water data for the non-P treated sorghum, and thus we are not able to test this hypothesis.

Long-term sorghum yields (Tables 11 & 12) are about 47 bu/A for the WSF and WSSF-1 rotation and about 35 bu/A for the second year sorghum in the WSSF-2 rotation. The second year sorghum yield is very similar to the average yield for continuous sorghum, which is what one would expect.

A continuous row-crop system (Table 12) has been a part of the experiment since its beginning. Grain sorghum was planted every year from 1986-1992. By harvest in 1992 the shatter cane weed problem was so severe that we planted corn in 1993 to allow us to use

herbicides that could control the shatter cane. Two additional plots were added to the experiment in 1993 so that we could test a rotation effect within the continuous row-crop system. Corn yields in the continuous system have averaged 26 bu/A overall soils and years. The highest corn yields, only 30 bu/A, were achieved on the sideslope soil in 1995. Obviously this system does not come close to generating adequate revenue to make corn production profitable.

Sunflower

Sunflower was planted following corn in the 4-year rotations at Sterling and Stratton as it was in 1994. Germination was erratic, but better than in 1994. An unidentified pest or disease problem severely damaged the stands, and we had to destroy the existing plants in mid-June. At Walsh sunflower was planted in the continuous row-cropping treatment in 1995. Seed yields were 6, 7, and 12 bu/A (390, 450, and 840 kg/ha) for summit, sideslope, and toeslope soils, respectively (Tables 8a v& 8b). For a year with very limited July and August rainfall, these yields were considered quite good.

Forage Sorghum

In the fall we measured biomass yields (Tables 13a & 13b) for the forage sorghum. This crop was planted at Sterling and Stratton when the sunflower crop failed. No additional fertilizer was applied beyond the amount supplied to the sunflower crop. Yields at Stratton were essentially double those at Sterling which reflects the dry August at Sterling, only 0.25 in. (5 mm) compared to 1.25 in. (3 O mm) at Stratton, and the better subsoil water conditions at Stratton (Table 29). The forage sorghum was planted on 12 July, harvested on 25 September, and produced from 1900 to 8100 lbs/A (2150-9140 kg/ha) of dry matter in 75 days of growth depending on soil position and water availability. It was an excellent “catch crop” to use when the sunflower crop failed.

Perennial Grass

Total biomass production of the perennial grasses was small compared to any other crop produced (Tables 14a & 14b). Toeslopes at Sterling and Stratton greatly out yielded the other two soil positions, but at Walsh the toeslope and summit were very similar, for which we have no logical explanation. Perennial grasses are at a yield disadvantage compared to annual plants because they must store large amounts of their photosynthate in the roots for survival, while annual plants channel most of their photosynthate into above ground growth. Over the 10 years since their establishment, the perennial grasses have received no nitrogen fertilizer, which further disadvantages them compared to our annual crops.

Crop Residue Base

Maintenance of crop residue cover during non-crop periods and during seedling growth stages is vital to maximizing water storage in the soil. Crop residues provide protection from raindrop impact, slow runoff, and decrease water evaporation rates from the soil. Cover greatly reduces erosion, both by wind and water.

Dynamics of the residue base in our systems are being monitored by soil and crop within

each rotation (Tables 15, 16, & 17). Residue loss between planting and harvest can be determined by subtracting the pre-harvest from the pre-plant residue amounts. Residue losses between planting and harvest are the result of decomposition by microorganisms, wind movement, and physical disruption during planting. We calculated residue totals after harvest by adding the new stover produced to the preharvest residue. The total at harvest represents the maximum amount available for protection against evaporation and erosion. Decomposition and physical weathering reduce the amount of residue in the time periods between crops. These periods of time can be as long as 14 months for the wheat-fallow rotation and as short as 7 months where sunflower follows corn or sorghum. Residue measurement over years will help us determine when the residue base reaches steady-state conditions.

Residue levels are subject to annual variations in climate both in terms of production and decomposition rates. Obviously drier years decrease production and also may decrease decomposition rates. The net effect is difficult to assess because the particular portion of the year that is extra dry or wet will change the direction of the impact. Residue quantities always are largest on toeslopes at each site, which is a function of productivity level. Walsh, the most stressed site historically, has had the lowest residue levels over all years.

Residue levels present just prior to wheat planting are the minimum point in all rotations because this time marks the end of the summer fallow period where decomposition has been occurring with no new additions of crop biomass. Therefore, cover is at its minimum, and erosion potential is at its maximum point. Residues present at wheat planting (Table 15) for WF were less than for either WCF or WCMF on all soils at all sites. This is directly attributable to less input of materials in the WF contrasted to the more intensive rotations. Residue levels in all rotations were lowest at the Walsh site because less biomass is produced and decomposition is encouraged by the longer growing season at that site. Residue amounts produced in each rotation were very similar at Sterling and Stratton because climatic differences between Sterling and Stratton are less dramatic than from Stratton to Walsh.

As noted in previous years, there were sizeable losses of residue from spring planting of corn or sorghum to fall harvest This 1oss is primarily due to microbial decomposition because warm temperatures, in combination with frequent summer rainfall events, promote rapid decomposition at the soil residue interface.

Soi1 Water

Soil water supplies plant demand between rainfall events. Soils of eastern Colorado cannot store sufficient water to sustain a crop for the whole season, even if at field capacity at planting time. We monitor soil water in our systems to determine how efficiently various rotations and crops within rotations are using water. Our concern is how well precipitation is captured in non-crop periods, and subsequently how efficiently water is used for plant growth. Soil water data are presented in Tables 18 to 35. We summarized data for the reader in various forms: (1) Total soil water use from planting to harvest by the wheat, corn, and sorghum crops in Tables 18 and 19; (2) Soil water use by depth increment for each crop in Tables 20-29: and (3) Plant available soil water by calendar date during the growing season for wheat, corn and sorghum in Tables 30-35.

Wheat:

The unusual climatic conditions during the growing season greatly affected wheat soil water use. At Sterling, for example, soils in the WF and WCF rotations gained 13 to 177 mm of water from planting time until harvest depending on soil position (Table 18). May and June rainfall totaled more than 300 mm (12 in.), which exceeded plant demand, and net soil water storage occurred. Summit and sideslope soils in the WCF rotation had approximately 50 less mm of stored water at planting than did these same soils in the WF and WCSF rotations. The shorter fallow period for the WCF rotation compared to the others was probably the reason for this observation.

Rainfall in the three months preceding wheat planting in 1994 totaled only 22 mm (0.88 in.) at Sterling, which contributed to the lesser amounts of stored water in all rotations compared to the situation at Stratton (Table 3a), where over 150 mm (6 in.) of rain fell in these same months. Soil profiles at Stratton contained almost double the amount of available water at wheat planting as compared to Sterling (Table 18). Late summer rainfall at Walsh also was adequate and soil profiles were well charged at planting except on the summit and sideslope positions in the WSSF rotation. We have no explanation for the latter observation. As noted in the wheat yield discussion the dry planting conditions at Sterling greatly affected our ability to control the downy brome populations and yields were reduced in W-F relative to the other rotations.

Wheat usually extracts soil water from depths as great as 5-6 feet (150-180 cm), but in 1995 the high amounts of rainfall in May and June at Sterling and Stratton (Table 3a) supplied enough water that subsoiI resources were not used to any great extent (Tables 20-23). At Walsh, however, where rainfall was near normal, the wheat used water from the 150-180 cm depth. Water extraction patterns for summit soils over the growing season are shown for each site in Tables 30-33, and reflect the effects of rainfall distribution.

Corn and Sorghum:

Soil water contents at corn or sorghum planting were excellent at all sites (Table 19). Second year sorghum in the WSSF rotation at Walsh had the smallest amount of available water at planting as would be expected because of the short recharge period in fall 1994 to sorghum planting in spring 1995. Precipitation for the intercrop period from wheat harvest to corn planting at Sterling totaled 330 mm, and 230 mm of it were stored by corn planting the first week in May, which is a 69% storage efficiency. Stratton received 400 mm of rainfall for this period and 195 mm were stored for a storage efficiency of 49%. Walsh received 540 mm of rainfall from wheat harvest until 8 June and 140 mm were stored for an efficiency of 26°/0. The low recovery at Walsh is partially attributable to receiving over 200 mm of rain in August of 1994, which was not efficiently stored.

Distribution of soil water at corn and sorghum planting and harvest is shown in Tables 24-27. Corn at Sterling and Stratton essentially extracted soil water from all depths down to 180 cm. Grain sorghum at Walsh used water from the 120-150 cm depth, but not from deeper layers. Refer to the discussion of yield for an explanation.

Soil water present in the summit soil at various dates during the corn and sorghum growing season for each soil depth are reported in Tables 34 and 35. These data show water extraction patterns with time. Corn at Sterling did not deplete the soil water as extensively as in other years, which may have been related to the herbicidal stunting that we believe occurred there.

Soil water on 10 August was still 113 mm, and based on this fact, one would have expected grain yields to have been better. This is further evidence for plant stunting; possibly herbicidal. Water extraction patterns by corn at Stratton were similar to those observed in previous years, as were sorghum water-extraction patterns at Walsh.

Water Storage after Wheat Harvest:

Water storage after wheat harvest was measured on summit and toeslope soils at all three locations beginning in June or July 1995 depending on wheat harvest date (Tables 30-33). At Sterling from 11 July to 10 August there was an average gain of 19 mm of water, which was 33% of the rainfall received. At Stratton from 12 July to 9 August there was an average gain of 16 mm of water, which was 26% of the rainfall received. At Walsh little rainfall was received after harvest in 1995. We would expect storage efficiencies to be relatively low for this time period because of the high air temperatures and extreme evaporative conditions.

Nitrogen and Phosphorus Contents of Grain and Stover

Nitrogen and P contents were determined for both grain and stover for each crop on each soil at each site (Tables 36-39). The reader can calculate crude protein content of grain by multiplying wheat grain N content by 5.7 and corn or sorghum grain N content by 6.3. All nutrient concentrations are on a dry weight basis, consequently crude protein levels will appear high compared to market levels. Therefore, a grain moisture correction must be applied to obtain market levels.

On a dry matter basis, wheat proteins averaged 13.1% at Sterling, 13.1% at Stratton and 13.8'% at Walsh (Table 36a). To correct these values for grain moisture content, multiply by 0.88, which results in an average of about 12% protein at all sites at market moisture levels. These values indicate that N fertilization was adequate for the wheat crop based on research by Goos, et al. (1 984). They established that if grain protein levels were above 11.1%, yield was not likely to be limited by N deficiency. Wheat straw N concentrations ranged from 0.27 to 0.71%; therefore each ton of straw contained from 5 to 14 lbs of N (Table 36b).

Nitrogen levels in corn and sorghum grain varied from 1.48 to 1.83 %, which is equivalent to 7.9 to 9.6% protein on a market moisture basis (Table 37a). Corn and sorghum stover N contents varied from 0.49 to 1.04%.(Table 37b). Each ton of corn or sorghum stalks therefore contained 10 to 21 lbs of N.

Nitrogen levels in forage sorghum (Table 38) ranged from 0.83 to 1.45%, which is equivalent to a range in crude protein of 5.2 to 9.1%. The average crude protein content was 7.4%.

Nitrogen levels in the perennial grass ranged from 0.31 to 0.65% with the highest levels generally occurring on the toeslope positions where soil N availability is highest. The average crude protein level for grass was 2.9°/0.

Soil Nitrate-Nitrogen

Residual soil NO_3-N analyses are routinely conducted on soil profile samples (0-6 ft or)-180 cm) taken prior to planting for each crop on each soil at each site (Table 40). These analyses are used to make fertilizer N applications for a particular crop on each soil at each site. Accumulation of residual nitrate allows reduction in the fertilizer rate. By using residual soil nitrate analyses of the root zone we can also determine if nitrate is leaching beneath the root

zone. With improved precipitation use efficiency in the more intensive crop rotations, the amount of nitrate escaping the root zone should be minimized. Generally over the past 5 years, the wheat-fallow system has had higher residual nitrates than the 3-or 4-year rotations at the end of fallow prior to wheat planting. The same was true in the 1994-95 crop year. Although less pronounced than the difference between wheat-fallow and the 3-year systems, the 4-year rotation have the least nitrate accumulation. Most likely the greater N removal in the intensive systems is causing this difference to occur.

CONCLUSIONS

Weather variations greatly affected the 1994-95 crop year. Unexpectedly late frost darnaged wheat yields at all sites, especially at Walsh. Sterling and Walsh experienced severe drought stress during the corn and sorghum growing season. Excellent levels of stored water at sorghum planting at Walsh prevented a sorghum crop failure, 75% of long-term yield, despite the less than 0.15 in. of rain during July and August.

More intensive rotations like wheat-corn(sorghum)-fallow and wheat-com(sorghum)-millet-fallow have more than doubled grain water use efficiency in all three study environments when compared over years. Water conserved in the no-till systems has been converted into increased grain production. In northeastern Colorado intensive rotations have increased dollar returns to land, labor, capital, management and risk by 25-40% compared to wheat-fallow practiced either with no-till or with conventional tillage. Because, historically, millet prices are relatively low, the wheat-corn-fallow has been more profitable than wheat-com-millet-fallow. In southeastern Colorado, even though the increased water use efficiency is achieved, the net returns favor wheat-fallow over the intensive rotations. The cost of sorghum production in our systems has been too high compared to the added yield received. Lower cost weed control systems are being tested at Walsh in an attempt to improve the profit potential of the intensive systems in that environment.

REFERENCES

Croissant, R. L., G.A. Peterson, and D.G. Westfall. 1992. Dryland cropping systems in eastern Colorado. Service in Action No. 516. Cooperative Extension. Colo. State Univ. Fort Collins, CO.

Goos, R.J., D.G. Westfall, and A.E. Ludwick. 1984. Grain protein content as an indicator of nitrogen fertilizer needs m winter wheat. Colorado State University Service in Action No. .555.

Greb, B. W., D.E. Smika, N.P. Woodruff and C.J. Whitfield. 1974. Summer fallow in the Central Great Plains. In: Summer Fallow in the Western United States. ARS-USDA. Conservation Research Report No. 17.

Peterson, G.A., D.G. Westfall, N.E. Toman, and R.L. Anderson. 1993a. Sustainable dryland cropping systems: economic analysis. Tech. Bul. TB93-3. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, W. Wood, and S. Ross. 1988. Crop and soil management in dryland agroecosystems. Tech. Bul. LTB88-6. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D.G. Westfall, W. Wood, L. Sherrod, and E. McGee. 1989. Crop and soil management in dryland agroecosystems. Tech. Bul. TB89-3. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, C.W. Wood, and E. McGee. 1990. Crop and soil management in dryland agroecosystems. Tech. Bu1. TB90- 1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, C.W. Wood, and E. McGee. 1991. Crop and soil management in dryland agroecosystems. Tech. Bul. TB91 -1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D.G. Westfall, L. Sherrod, E. McGee, and R. Kolberg. 1992. Crop and soil management in dryland agroecosystems. Tech. Bu1. TB92-2. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and B. Rouppet. 1993b. Sustainable dryland agroecosystem management. Tech. Bul. TB93-4. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and B. Rouppet. 1994. Sustainable dryland agroecosystem management. Tech. Bul. TB94- 1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D.G. Westfall, L. Sherrod, R. Kolberg, and D. Poss. 1995. Sustainable dryland agroecosystem management. Tech. Bul. TB95- 1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Wood, C. W., D. G. Westfall, G. A. Peterson and I. C. Burke. 1990. Impacts of cropping intensity on carbon and nitrogen mineralization under no-till agroecosystems. Agron. J. 82:1115-1120.

Table 2. Nitrogen fertilizer application by soil and crop for 1995.

SITE	SOIL	CROP	ROTATION				
			WF	WCF	WCMF	OPP	
			----------Lb/A ----------				
Sterling	Summit	Wheat	41	52	52	52	
	Sideslope	"	41	52	52	52	
	Toeslope	"	41	52	52	52	
	Summit	Corn		83	83		
	Sideslope	"		83	83		
	Toeslope	"		83	83		
	Summit	Sunflower			31		
	Sideslope	"			31		
	Toeslope	"			31		
			WF	WCF	WCMF	OPP	
Stratton	Summit	Wheat	41	52	52	41	
	Sideslope	"	41	52	52	41	
	Toeslope	"	41	52	52	41	
	Summit	Corn		83	83		
	Sideslope	"		83	83		
	Toeslope	"		83	83		
	Summit	Sunflower			31		
	Sideslope	"			31		
	Toeslope	"			31		
			WF	WSF	WSSF	OPP	CONT. CROP
Walsh	Summit	Wheat	38	48	63	48	
	Sideslope	"	38	48	63	48	
	Toeslope	"	38	48	63	48	
	Summit	Sorghum1		56	81		
	Sideslope	"		56	81		
	Toeslope	"		56	81		
	Summit	Sorghum2			81		
	Sideslope	"			81		
	Toeslope	"			81		
	Summit	Corn					75
	Sideslope	"					75
	Toeslope	"					75
	Summit	Sunflower					30
	Sideslope	"					30
	Toeslope	"					30

Table 3a. **Monthly precipitation for each site for the 1994-95 growing season.**

MONTH	LOCATION					
	STERLING		STRATTON		WALSH	
	Inches					
1994	1994	Normals	1994	Normals	1994	Normals
JULY	0.00	2.40	3.46	2.60	2.64	3.10
AUGUST	0.18	2.00	2.63	2.30	8.35	2.30
SEPTEMBER	0.70	1.20	0.18	1.60	0.50	1.30
OCTOBER	3.77	1.00	2.71	1.00	1.23	1.10
NOVEMBER	0.69	0.70	1.16	0.70	0.85	0.60
DECEMBER	0.62	0.60	0.36	0.40	0.26	0.30
SUBTOTAL	5.96	7.90	10.50	8.60	13.83	8.70
1995	1995	Normals	1995	Normals	1995	Normals
JANUARY	0.46	0.50	1.21	0.40	0.85	0.40
FEBRUARY	0.30	0.50	0.95	0.40	0.45	0.30
MARCH	0.77	1.30	0.42	1.00	0.48	0.70
APRIL	2.11	2.00	1.69	1.60	1.03	1.30
MAY	6.08	3.00	4.10	2.70	4.07	2.50
JUNE	6.19	2.80	4.22	2.40	2.07	2.70
SUBTOTAL	15.91	10.10	12.59	8.50	8.95	7.90
1995	1995	Normals	1995	Normals	1995	Normals
JULY	2.53	2.40	2.74	2.60	0.13	3.10
AUGUST	0.25	2.00	1.26	2.30	0.01	2.30
SEPTEMBER	2.16	1.20	1.21	1.60	0.74	1.30
OCTOBER	0.00	1.00	0.21	1.00	0.14	1.10
NOVEMBER	0.49	0.70	0.49	0.70	0.00	0.60
DECEMBER	0.05	0.60	0.06	0.40	0.85	0.30
SUBTOTAL	5.48	7.90	5.97	8.60	1.87	8.70
YEAR TOTAL	21.39	18.00	18.56	17.10	10.82	16.60
18 MONTH TOTAL	27.35	25.90	29.06	25.70	24.65	25.30

Table 3b. Precipitation summary by growing season segments for Sterling from 1987-1995.

Year	Growing Season Segments				
	Wheat		Corn		
	Vegetat. Sep - Mar	Reprod. Apr - Jun	Preplant Jul - Apr	Growing Season May - Ott	
	Inches				
1987-88	5.2	9.9	11.1	15.8	
1988-89	3.1	6.5	10.5	14.3	
1989-90	5.1	4.7	11.8	13.0	
1990-91	3.8	7.2	12.3	11.7	
1991-92	4.5	4.8	9.1	14.8	
1992-93	4.5	6.2	15.5	10.6	
1993-94	6.4	3.0	10.2	6.1	(3.8” in October)
1994-95	7.3	14.4	9.6	17.2	(12” in May and June)
Long Term Average	5.8	7.8	12.2	12.4	

Table 3c. Precipitation summary by growing season segments for Stratton from 1987-1995.

Year	Growing Season Segments				
	Wheat		Corn		
	Vegetat. Sep - Mar	Reprod. Apr - Jun	Preplant Jul - Apr	Growing Season May - Ott	
	Inches				
1987-88	4.3	7.2	8.8	12.6	
1988-89	3.0	9.4	5.3	15.5	
1989-90	5.3	6.1	11.0	13.4	
1990-91	4.4	4.1	10.7	14.7	
1991-92	3.3	6.1	14.2	13.6	
1992-93	3.3	3.8	11.8	14.7	
1993-94	4.3	7.8	16.7	13.5	(2.7” in October)
1994-95	7.0	10.0	14.8	13.7	(8” in May and June)
Long Term Average	5.5	6.7	12.0	12.6	

Table 3d. Precipitation summary by growing season segments for Walsh from 19987-95

Year	Growing Season Segments			
	Wheat		Sorghum	
	Vegetat. Sep - Mar	Reprod. Apr - Jun	Preplant Jul - Apr	Growing Season May - Ott
	Inches			
1987-88	4.3	7.6	7.4	11.1
1988-89	4.1	11.5	8.1	20.2
1989-90	5.7	7.4	14.1	12.5
1990-91	5.0	7.7	11.7	12.2
1991-92	2.7	5.8	7.1	13.2
1992-93	6.1	9.2	13.8	14.5
1993-94	3.2	5.3	8.7	16.3 (8.4” in August)
1994-95	4.6	7.2	16.6	7.2
Long Term Average	4.7	6.5	11.4	13.0

Table 4a. Grain and stover yields for WHEAT in English units in 1995.

SITE & ROTATION	SLOPE POSITION: SUMMIT GRAIN NP*	SUMMIT GRAIN NP	SUMMIT STOVER NP*	SUMMIT STOVER NP	SIDESLOPE GRAIN NP*	SIDESLOPE GRAIN NP	SIDESLOPE STOVER NP*	SIDESLOPE STOVER NP	TOESLOPE GRAIN NP*	TOESLOPE GRAIN NP	TOESLOPE STOVER NP*	TOESLOPE STOVER NP
STERLING:	----- Bu.IA. ------		------ IbsJA. -----		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WF	18	15	2786	2492	8	16	963	2275	12	14	2204	3044
WCF	31	30	5122	4462	37	25	3864	3300	28	31	3375	2999
WCSF	28	20	4253	3377	35	34	3832	3843	34	26	4965	3608
OPP	27	25	5679	3296	32	31	3333	3362	35	28	4686	4542
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STRATTON:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WF	44	38	5420	5381	33	32	4255	3921	40	40	7337	6414
WCF	43	44	4366	5136	33	35	3371	3956	56	57	6266	7235
WCSF	39	42	5112	5077	34	36	3802	4233	53	43	7319	6205
OPP	59	55	6502	7971	41	47	4652	5883	50	49	5966	6906
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
WALSH:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WF	16	16	1896	2481	15	15	2079	2031	15	16	1977	2451
WSF	15	13	1906	2020	16	14	1883	2040	18	16	1939	2376
WSSF	11	12	1579	1725	15	10	1836	1256	16	16	1964	1679
OPP	10	13	f395	1806	13	11	1614	1836	22	15	2550	2156

1. Wheat grain yield expressed at 12% moisture.

•Only receives phosphorus in wheat phase of each rotation.

Table 4b. Grain, stover and biomass yields for WHEAT in 1996.

SITE & ROTATION	SLOPE POSITION: SUMMIT GRAIN NP*	SUMMIT GRAIN NP	SUMMIT STOVER NP*	SUMMIT STOVER NP	SUMMIT TOTAL NP*	SUMMIT TOTAL NP	SIDE GRAIN NP*	SIDE GRAIN NP	SIDE STOVER NP*	SIDE STOVER NP	SIDE TOTAL NP*	SIDE TOTAL NP	TOE GRAIN NP*	TOE GRAIN NP	TOE STOVER NP*	TOE STOVER NP	TOE TOTAL NP*	TOE TOTAL NP
STERLING:	Kg/ha						Kg/ha						Kg/ha					
WF	1229	1025	3098	2791	4327	3816	519	1091	1078	2547	1597	3638	808	933	2469	3409	3277	4342
WCF	2076	1995	5737	4997	7813	6992	2485	1713	4328	3696	6813	5409	1895	1444	3780	3359	5675	4803
WCSF	1867	1327	4764	3782	6631	5109	2384	2258	4291	4305	6675	6563	2284	1758	5561	4041	7845	5799
OPP	1815	1679	6360	3692	8175	5371	2137	2062	3733	3766	5870	5828	2328	1897	5248	5088	7576	6985
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STRATTON:	Kg/ha						Kg/ha						Kg/ha					
WF	2944	2530	6070	6027	9014	8557	2248	2164	4765	4391	7013	6555	2661	2715	8218	7184	10879	9899
WCF	2893	2959	4890	5754	7783	8713	2244	2345	3775	4431	6019	6776	3778	3825	7017	8103	10795	11928
WCSF	2649	2581	5725	5686	8374	8267	2261	2390	4258	4741	6519	7131	3589	2906	8198	6949	11787	9855
OPP	3974	3711	7282	8928	11256	12639	2748	3136	5211	6589	7959	9725	3374	3303	6682	7735	10056	11038
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
WALSH:	Kg/ha						Kg/ha						Kg/ha					
WF	1046	1080	2124	2779	3170	3859	1010	1010	2329	2274	3339	3284	1033	1102	2214	2451	3247	3553
WSF	1034	872	2137	2262	3171	3134	1099	944	2109	2285	3208	3229	1209	1049	2172	2661	3381	3710
WSSF	724	793	1768	1932	2492	2725	1020	681	2056	1407	3076	2088	1079	1086	2199	1881	3278	2967
OPP	694	876	1563	2022	2257	2898	844	751	1807	2056	2651	2807	1499	987	2856	2415	4355	3402

1. Wheat grain yield expressed at 12% moisture.

* Only receives phosphorus in wheat phase of each rotation.

Table 5. Wheat yields at optimum fertility by year and soil position at Sterling from 1986-1995.

YEAR	SLOPE POSITION			
	SUMMIT	SIDE	TOE	MEAN
	Bu/A			
1986	27	25	28	27
1987	22	15	25	21
1988	18	27	19	21
1989	36	38	46	40
1990	35	34	47	39
1991	31	29	41	34
1992	17	18	35	23
1993	41	38	52	44
1994	22	28	36	29
1995*	27	28	30	28
MEAN	28	28	36	31

*Averages do not include wheat-fallow, which was infested with downy brome.

Table 6. Wheat yields at optimum fertility by year and soil position at Stratton from 1986-1995.

YEAR	SLOPE POSITION			
	SUMMIT	SIDE	TOE	MEAN
	Bu/A			
1986	32	29	23	28
1987	27	20		24
1988	38	43	49	43
1989	43	31	87	54
1990	48	53	72	58
1991	49	40	56	48
1992	29	29	31	30
1993	36	35	51	41
1994	37	35	51	41
1995	46	36	48	43
MEAN	39	35	52	42

Table 7. Wheat yields at optimum fertility by year and soil position at Walsh from 1986-1995.

YEAR	SLOPE POSITION			
	SUMMIT	SIDE	TOE	MEAN
	Bu/A			
1986	No wheat produced this year			
1987	34	32	48	38
1988	No wheat produced this year			
1989	24	27	28	26
1990	24	28	32	28
1991	32	34	48	38
1992	25	39	53	39
1993	34	39	42	38
1994	33	37	44	38
1995	13	14	17	15
MEAN	24	31	39	32

Table 8a. Grain and stover yields for CORN and SORGHUM in English units in 1995.

SITE & ROTATION	SLOPE POSITION											
	SUMMIT				SIDESLOPE				TOESLOPE			
	GRAIN		STOVER		GRAIN		STOVER		GRAIN		STOVER	
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STERLING:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WCF	13	10	634	680	11	8	636	515	26	17	1363	866
WCSF	8	10	446	671	10	8	812	474	38	36	1704	1497
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STRATTON:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WCF	28	20	1079	952	26	20	1235	989	62	57	6626	2380
WCSF	34	21	1420	1078	33	36	1473	1464	54	53	2030	2264
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
WALSH:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WSF	27	32	1050	1191	43	36	2096	1428	31	37	1318	2198
WSSF-1	23	25	741	821	28	28	1062	907	40	32	1570	1576
WSSF-2	18	23	568	751	19	28	640	996	21	20	885	914
CS (Sunflower)	6	6	1073	1028	6	7	1191	1587	13	11	2214	1599
CS (Corn)	17	27	1202	1662	16	30	1016	1797	22	29	1262	1660

1, Corn grain yield expressed et 15.5% moisture.

2. Sorghum grain yield expressed at 14% moisture.

Table 8b. Grain, stover and biomass yields for CORN and SORGHUM in 1996.

SITE & ROTATION	SLOPE POSITION																	
	SUMMIT						SIDE						TOE					
	GRAIN		STOVER		TOTAL		GRAIN		STOVER		TOTAL		GRAIN		STOVER		TOTAL	
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STERLING:	Kg/ha						Kg/ha						Kg/ha					
WCF	786	603	710	761	1496	1364	674	497	713	577	1387	1074	1643	1040	1526	970	3169	2010
WCSF	501	622	500	752	1001	1374	599	508	910	531	1509	1039	2383	2233	1909	1677	4292	3910
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STRATTON:	Kg/ha						Kg/ha						Kg/ha					
WCF	1728	1227	1209	1066	2937	2293	1658	1260	1383	1107	3041	2367	3877	3596	7421	2665	11298	6261
WCSF	2129	1314	1590	1208	3719	2522	2090	2228	1649	1639	3739	3867	3376	3317	2274	2536	5650	5853
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
WALSH:	Kg/ha						Kg/ha						Kg/ha					
WSF	1703	2033	1176	1334	2879	3367	2694	2251	2347	1599	5041	3850	1944	2345	1476	2462	3420	4807
WSSF-1	1441	1540	830	920	2271	2460	1785	1767	1190	1016	2975	2783	2484	1983	1758	1765	4242	3748
WSSF-2	1132	1429	636	841	1768	2270	1162	1741	716	1116	1878	2857	1286	1277	991	1023	2277	2300
CS (Sunflower)	393	386	1201	1151	1594	1537	423	477	1334	1777	1757	2254	897	716	2480	1791	3377	2507
CS (Corn)	1048	1723	1346	1861	2394	3584	1020	1895	1138	2012	2158	3907	1368	1790	1413	1860	2781	3650

1. Corn grain yield expressed at 15.5% moisture.
2. Sorghum grain yield expressed at 14% moisture.

Table 9. Corn yields at optimum fertility by year and soil position at Sterling from 1986-1995.

YEAR	SLOPE POSITION			
	SUMMIT	SIDE	TOE	MEAN
	Bu/A			
1986	48	34	70	51
1987	47	59	70	59
1988	61	71	78	70
1989	52	74	102	76
1990	66	80	104	83
1991	55	69	105	76
1992	84	87	120	97
1993	43	50	70	54
1994	4	17	22	14
1995	10	12	29	17
MEAN	47	55	77	60

Table 10. Corn and sorghum yields at optimum fertility by year and soil position at Stratton from 1986-1995.

YEAR	SLOPE POSITION			
	SUMMIT	SIDE	TOE	MEAN
	Bu/A			
1986	52	38	99	63
1987	30	34	51	38
1988	42	46	78	55
1989	21	15	24	20
MEAN	36	33	63	44
Corn replaced sorghum beginning in 1990				
1990	54	54	88	65
1991	89	79	117	95
1992	82	76	111	90
1993	64	74	94	77
1994	48	34	68	50
1995	26	29	56	37
MEAN	61	58	89	69

Table 11. Rotation sorghum yields at optimum fertility by year and soil position at Walsh from 1986-1995.

YEAR	SLOPE POSITION			
	SUMMIT	SIDE	TOE	MEAN
	----------Bu/A----------			
1986	35	26	44	35
1987	29	31	20	27
1988	43	47	72	54
1989	18	28	85	44
1990	24	37	76	46
1991	33	49	64	49
1992	44	54	56	51
1993	50	54	56	53
1994	62	63	97	74
1995*	27	34	35	32
MEAN	37	42	61	46

'Average of WSF and WSSF-1

Table 12. Continuous row crop yields at optimum fertility by year and soil position at Walsh from 1986-1995.

YEAR	SLOPE POSITION				
	SUMMIT	SIDE	TOE	MEAN	CROP
	----------Bu/A----------				
1986	35	26	44	35	Sorghum
1987	29	26	13	23	Sorghum
1988	39	21	66	42	Sorghum
1989	31	27	70	43	Sorghum
1990	44	33	47	41	Sorghum
1991	43	41	38	41	Sorghum
1992	42	48	49	46	Sorghum
1993	22	20	31	24	Corn
1994	24	20	21	22	Sorghum
1995	27	30	26	28	Corn
MEAN	34	29	41	34	

Table 13a. Forage Sorghum biomass yields for 1995 (lbs/A).

SITE & ROTATION	SLOPE POSITION: SUMMIT BIOMASS N	SUMMIT BIOMASS NP	SIDE BIOMASS N	SIDE BIOMASS NP	TOE BIOMASS N	TOE BIOMASS NP
STERLING:	----lbs/A----		---lbs/A---		---lbs/A---	
WCSF	2842	3813	1921	2288	3071	2379
	N	NP	N	NP	N	NP
STRATTON:						
WCSF	8152	7382	3827	3510	7762	7889

Table 13b. Forage Sorghum biomass yields for 1995 (kg/ha).

SITE & ROTATION	SLOPE POSITION: SUMMIT BIOMASS N	SUMMIT BIOMASS NP	SIDE BIOMASS N	SIDE BIOMASS NP	TOE BIOMASS N	TOE BIOMASS NP
STERLING:	----Kg/ha----		----Kg/ha----		----Kg/ha----	
WCSF	3187	4275	2154	2575	3071	2379
	N	NP	N	NP	N	NP
STRATTON						
WCSF	9141	8255	4068	3936	8704	8824

Table 14a. Perrennial Grass yields for 1996 lbs/A.

	SLOPE POSITION		
	SUMMIT	SIDE	TOE
SITE & ROTATION	*BIOMASS*	*BIOMASS*	*BIOMASS*
	SUMMIT	SIDE	TOE
STERLING:	----lbs/A---	---lbs/A---	---lbs/A---
GRASS	1224	1241	2107
STRATTON:			
GRASS	1134	1215	4509
WALSH.			
GRASS	1353	485	1473

Table 14b. Perrennial Grass yields for 1996 Kg/ha.

	SLOPE POSITION		
	SUMMIT	SIDE	TOE
SITE & ROTATION	*BIOMASS*	*BIOMASS*	*BIOMASS*
	SUMMIT	SIDE	TOE
STERLING:	—Kg/ha—	—Kg/ha—	—Kg/ha—
GRASS	1372	1392	2362
STRATTON:			
GRASS	1272	1363	5056
WALSH:			
GRASS	1517	544	1652

Table 15. Residue surface weights on all plots in WHEAT during the 1994-199S crop year.

SITE & ROTATION	SLOPE POSITION: SUMMIT — SAMPLING TIME AND TOTAL RESIDUE: Pre-Plant		Pre-Harvest		Stover		Total at Harvest	
	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STERLING:	Kg/ha							
WF	3084	4907	1524	2449	3098	2791	4622	5240
WCF	4298	5164	1644	2418	5737	4997	7381	7415
WCSF	3956	6507	1267	1130	4764	3782	6031	4912
OPP	5453	5387	1622	3796	6360	3692	7982	7488
	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STRATTON:	Kg/ha							
WF	1653	1729	1249	5804	6070	6027	7319	11831
WCF	3244	5031	3111	1791	4890	5754	8001	7545
WCSF	3969	5040	3916	4947	5725	5686	9641	10633
OPP	6129	4627	3009	2827	7282	8928	******	11755
	NP*	NP	NP*	NP	NP*	NP	NP*	NP
WALSH:	Kg/ha							
WF	649	876	960	1476	2124	2779	3084	4255
WSF	1413	1676	1436	1560	2137	2262	3573	3822
WSSF	1418	2507	1347	2538	1768	1932	3115	4470
OPP	1787	1458	2716	4622	1563	2022	4279	6644

SLOPE POSITION: SIDESLOPE — SAMPLING TIME AND TOTAL RESIDUE: Pre-Plant		Pre-Harvest		Stover		Total at Harvest	
NP*	NP	NP*	NP	NP*	NP	NP*	NP
Kg/ha							
2062	4213	1858	800	1078	2547	2936	3347
5400	5782	3356	3209	4328	3696	7684	6905
5956	5662	2342	4289	4291	4305	6633	8594
7520	8973	2356	2431	3733	3766	6089	6197
NP*	NP	NP*	NP	NP*	NP	NP*	NP
Kg/ha							
1764	3311	2129	1578	4765	4391	6894	5969
4756	6671	760	2676	3775	4431	4535	7107
4023	4604	1004	1987	4258	4741	5262	6728
6942	4809	3667	1769	5211	6589	8878	8358
NP*	NP	NP*	NP	NP*	NP	NP*	NP
Kg/ha							
769	1138	2289	3600	2329	2274	4618	5874
2231	1644	1178	1396	2109	2285	3287	3681
1542	2129	1191	1649	2056	1407	3247	3056
529	2969	4236	2213	1807	2056	6043	4269

SLOPE POSITION: TOESLOPE — SAMPLING TIME AND TOTAL RESIDUE: Pre-Plant		Pre-Harvest		Stover		Total at Harvest	
NP*	NP	NP*	NP	NP*	NP	NP*	NP
Kg/ha							
4733	4324	1951	884	2469	3409	4420	4293
5627	6364	1240	2471	3760	3359	5020	5830
4987	6596	1587	1062	5561	4041	7148	5103
7311	11027	2867	2560	5248	5088	8115	7648
NP*	NP	NP*	NP	NP*	NP	NP*	NP
Kg/ha							
5320	3382	5387	4324	8218	7184	******	11508
7031	5489	2791	4444	7017	6103	9808	12547
5324	5089	2756	2053	8198	6949	******	9002
4849	6640	2613	1364	6682	7735	9295	9099
NP*	NP	NP*	NP	NP*	NP	NP*	NP
Kg/ha							
1520	2476	1449	2289	2214	2451	3663	4740
3151	2000	716	2378	2172	2661	2888	5039
3782	1587	2627	2102	2199	1881	4826	3983
1329	1911	2871	3569	2856	2415	5727	5984

1. For conversion to lbs/Acre multiply Kg/ha by 0.893.
* Only receives phosphorus in wheat phase of each rotation.

Table 16. Residue surface weights on all plots in CORN during the 1995 crop year.

SITE & ROTATION	SLOPE POSITION																			
	SUMMIT								SIDESLOPE								TOESLOPE			
	SAMPLING TIME AND TOTAL RESIDUE								SAMPLING TIME AND TOTAL RESIDUE								SAMPLING TIME AND TOTAL RESIDUE			
	Pre-Plant		*Pre-Harvest*		*Stover*		*Total at Harvest*		*Pre-Plant*		*Pre-Harvest*		*Stover*		*Total at Harvest*		*Pre-Plant*		*Pre-Harvest*	
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STERLING:	Kg/ha								Kg/ha								Kg/ha			
WCF	3707	3338	1796	2809	710	761	2506	3570	4582	5364	1013	1804	713	577	1726	2381	5880	7449	2956	3502
WCSF	1142	7387	1316	956	500	752	1816	1708	3467	6658	2382	2040	909	531	3291	2571	5524	2831	3316	3378
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STRATTON:	Kg/ha								Kg/ha								Kg/ha			
WCF	3284	3796	2911	3276	1208	1066	4119	4342	2809	2262	1013	1804	1383	1107	2396	2911	5281	4129	2587	1311
WCSF	2022	3147	1138	1222	1590	1208	2728	2430	3262	3182	2169	1378	1649	1639	3818	3017	5344	2980	1787	1440
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
WALSH:	Kg/ha								Kg/ha								Kg/ha			
WSF	3804	5751	3458	1751	1176	1334	4634	3085	5164	4804	2293	1911	2347	1599	4640	3510	3244	3769	1013	1804
WSSF-1	4942	1982	1520	1067	830	920	2350	1987	4489	2027	1920	711	1189	1016	3109	1727	2000	2978	1227	942
WSSF-2	3147	3236	1013	1804	636	841	1649	2645	4098	2916	2142	2036	716	1115	2858	3151	3320	4471	3236	3298
CS (SUNFLOWE	3404	2013	1280	1991	1201	1151	2481	3142	2267	2453	1031	1538	1334	1777	2365	3315	3893	2871	3431	2338
CS (Corn)			--	--	1346	1861	1346	1861			--	--	1138	2012	1138	2012			--	--

SITE & ROTATION	SLOPE POSITION							
	TOESLOPE							
	SAMPLING TIME AND TOTAL RESIDUE							
	Stover		*Total at Harvest*					
	N	NP	N	NP				
STERLING:	Kg/ha							
WCF	1526	970	4482	4472				
WCSF	1909	1677	5225	5055				
	N	NP	N	NP				
STRATTON:	Kg/ha							
WCF	7421	2665	10008	3976				
WCSF	2273	2536	4060	3976				
	N	NP	N	NP				
WALSH:	Kg/ha							
WSF	1476	2462	2489	4266				
WSSF-1	1758	1765	2985	2707				
WSSF-2	991	1023	4227	4321				
CS (SUNFLOWE	2480	1791	5911	4129				
CS (Corn)	1413	1860	1413	1860				

1. For conversion to lbs/Acre multiply Kg/ha by 0.893.

Table 17. Residue surface weights on all plots in FORAGE SORGHUM in 1995.

SITE & ROTATION	SLOPE POSITION																			
	SUMMIT								SIDESLOPE								TOESLOPE			
	SAMPLING TIME AND TOTAL RESIDUE								SAMPLING TIME AND TOTAL RESIDUE								SAMPLING TIME AND TOTAL RESIDUE			
	Pre-Plant		*Pre-Harvest*		*Stover*		*Total at Harvest*		*Pre-Plant*		*Pre-Harvest*		*Stover*		*Total at Harvest*		*Pre-Plant*		*Pre-Harvest*	
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STERLING:	Kg/ha								Kg/ha								Kg/ha			
WCSF	4791	7236	1874	2235	1474	1715		3950	4849	6551	1671	2199	1016	1300	2687	3499	4996	2551	1846	1910
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STRATTON	Kg/ha								Kg/ha								Kg/ha			
WCSF	6476	6209	2330	3961	1616	2054	3946	6015	4320	2520	1373	1842	1256	1529	2629	3371	7573	7610	2151	3505

SITE & ROTATION	TOESLOPE							
	Stover		*Total at Harvest*					
	N	NP	N	NP				
STERLING:								
WCSF	1682	1060	3528	2970				
	N	NP	N	NP				
STRATTON								
WCSF	1758	1366	3909	4871				

1. For conversion to lbs/Acre multiply Kg/ha by 0.893.

Table 18. Available soil water at planting and harvest for WHEAT in the 1994-95 growing season.

SITE & ROTATION	SLOPE POSITION: SUMMIT 1994 PLANTING	SUMMIT 1995 HARVEST	SUMMIT CHANGE	SIDESLOPE 1994 PLANTING	SIDESLOPE 1995 HARVEST	SIDESLOPE CHANGE	TOESLOPE 1994 PLANTING	TOESLOPE 1995 HARVEST	TOESLOPE CHANGE
	mm/30cm			mm/30cm			mm/30cm		
STERLING:									
WF	103 *	127 *	-24 *	143 *	156 *	-13 *	131	244	-113
WCF	55 *	120 *	-65 *	75 *	128 *	-53 *	130	307	-177
WCSF	105 *	89 *	16 *	155 *	150 *	5 *	207	250	-43
OPP	150 *	90 *	60 *	212 *	167 *	45 *	244	186	58
STRATTON:									
WF	201	141	60	252	194	58	416	346	70
WCF	196	142	54	233	221	12	395	277	118
WCSF	203	157	46	271	237	34	331	244	87
OPP	198	94	104	241	183	58	349	250	99
WALSH:									
WF	199	21	178	160	53	107	262	33	229
WSF	219	53	166	113	26	87	319	66	253
WSSF	73	122	-49	20	118	-98	229	75	154
OPP	244	80	164	163	39	124	288	88	200

1. To convert from millimeters of H20/1.8 meters of soil to inches of H20/6 feet of soil multiply by 0.04.

* millimeters/1.2 meters

Table 19. Available soil water at planting and harvest for CORN and SORGHUM in the 1995 growing season.

SITE & ROTATION	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
STERLING:									
WCF	190 *	51 •	139 *	205 •	81 •	124 •	287	96	191
WCSF	219 •	99 •	120 *	173 *	37 *	136 *	301	99	202
STRATTON:									
WCF	219	52	167	243	64	179	412	194	218
WCSF	195	46	149	263	90	173	304	112	192
WALSH:									
WSF	229	105	124	208	53	155	227	88	139
WSSF(1)	213	68	145	187	64	123	212	85	127
WSSF(2)	160	118	42	143	53	90	156	41	115
CS (Corn)	212	117	95	89	6	83	190	105	85
CS (Sunflower)	168	44	124	135	37	98	243	86	157

1. To convert from millimeters of H20/1.8 meters of soil to inches of H20/6 feet of soil multiply by 0.04.

* millimeters/1.2 meters

Table 20. Available soil water by soil depth in the WHEAT phase of the WF rotation at Sterling, Stratton, and Walsh in 1994-95.

SITE & DEPTH (cm)	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
STERLING:									
15	33	45	-12	44	43	1	36	57	-21
45	18	30	-12	27	40	-13	25	45	-20
75	23	24	-1	40	29	11	31	40	-9
105	29	28	1	32	44	-12	20	26	-6
135							8	31	-23
155							11	45	-34
TOTAL	103	127	-24	143	156	-13	131	244	-113
STRATTON:									
15	39	23	16	58	45	13	77	57	20
45	34	20	14	43	29	14	65	36	29
75	29	18	11	42	33	9	80	58	22
105	30	22	8	33	29	4	84	81	3
135	35	30	5	38	33	5	55	58	-3
155	34	28	6	38	25	13	55	56	-1
TOTAL	201	141	60	252	194	58	416	346	70
WALSH:									
15	31	0	31	40	16	24	43	0	43
45	20	0	20	37	10	27	33	9	24
75	24	2	22	19	6	13	36	6	30
105	34	0	34	8	11	-3	47	0	47
135	41	1	40	25	0	25	43	0	43
155	49	18	31	31	10	21	60	18	42
TOTAL	199	21	178	160	53	107	262	33	229

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 21. Available soil water by soil depth in the WHEAT phase of the WCF rotation at Sterling and Stratton and WHEAT phase of the WSF rotation at Walsh in 1994-95.

SITE & DEPTH (cm)	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
STERLING:									
15	22	50	-28	29	45	-16	35	65	-30
45	10	34	-24	21	15	6	25	53	-28
75	13	20	-7	13	24	-11	25	56	-31
105	10	16	-6	12	44	-32	25	40	-15
135				-	-	-	13	37	-24
155				-	-	-	7	56	-49
TOTAL	55	120	-65	75	128	-53	130	307	-177
STRATTON:									
15	37	14	23	41	27	14	70	40	30
45	36	24	12	34	43	-9	73	28	45
75	30	21	9	42	55	-13	78	51	27
105	32	25	7	31	40	-9	69	60	9
135	32	29	3	31	34	-3	44	41	3
155	29	29	0	54	22	32	61	57	4
TOTAL	196	142	54	233	221	12	395	277	118
WALSH:									
15	35	0	35	42	0	42	48	0	48
45	34	5	29	39	8	31	37	3	34
75	29	0	29	16	5	11	46	0	46
105	44	10	34	0	2	-2	57	12	45
135	39	23	16	7	0	7	47	12	35
155	38	15	23	9	11	-2	84	39	45
TOTAL	219	53	166	113	26	87	319	66	253

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 22. Available soil water by soil depth in the WHEAT phase of the WCSF rotation at Sterling and Stratton and WHEAT phase of the WSSF Rotation at Walsh in 1994-95. ,

SITE & DEPTH (cm)	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
STERLING:									
15	39	36	3	36	34	2	42	51	-9
45	25	15	10	42	29	13	21	42	-21
75	19	24	-5	39	40	-1	43	49	-6
105	22	14	8	38	47	-9	51	33	18
135	-	-	-	-	-	-	30	38	-8
155	-	-	-	-	-	-	20	37	-17
TOTAL	105	89	16	155	150	5	207	250	-43
STRATTON:									
15	47	27	20	51	38	13	70	40	30
45	35	28	7	39	31	8	61	41	20
75	27	20	7	46	42	4	64	43	21
105	31	25	6	42	41	1	60	52	8
135	31	26	5	43	43	0	43	39	4
155	32	31	1	50	42	8	33	29	4
TOTAL	203	157	46	271	237	34	331	244	87
WALSH:									
15	13	0	13	13	10	3	27	5	22
45	10	7	3	4	12	-8	14	0	14
75	8	13	-5	0	10	-lo	22	3	19
105	10	20	-10	0	30	-30	46	22	24
135	14	40	-26	0	21	-21	41	19	22
155	18	42	-24	3	35	-32	79	26	53
TOTAL	73	122	-49	20	118	-98	229	75	154

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 23. Available soil water by soil depth in the WHEAT phase of the OPPORTUNITY cropping rotation in 1994-95.

SITE & DEPTH (cm)	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
STERLING:									
15	48	34	14	37	40	-3	45	52	-7
45	50	15	35	50	37	13	44	35	9
75	23	17	6	64	45	19	52	39	13
105	29	24	5	61	45	16	57	24	33
135	-	-	-	-	-	-	26	27	-1
155	-	-	-	-	-	-	20	9	11
TOTAL	150	90	60	212	167	45	244	186	58
STRATTON:									
15	44	11	33	46	33	13	69	40	29
45	39	13	26	30	18	12	58	29	29
75	30	10	20	35	24	11	76	62	14
105	31	20	11	52	45	7	62	47	15
135	26	18	8	40	35	5	41	37	4
155	28	22	6	38	28	10	43	35	8
TOTAL	198	94	104	241	183	58	349	250	99
WALSH:									
15	34	0	34	47	16	31	47	4	43
45	31	3	28	42	16	26	33	6	27
75	46	5	41	20	2	18	44	4	40
105	49	21	28	0	0	0	58	18	40
135	41	27	14	29	0	29	37	21	16
155	43	24	19	25	5	20	69	35	
TOTAL	244	80	164	163	39	124	288	88	166

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 24. Available soil water by soil depth in the CORN phase of the WCF rotation at Sterling and Stratton and SORGHUM phase of the WSF rotation at Walsh in 1995.

SITE & DEPTH (cm)	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
STERLING:									
15	43	21	22	41	23	18	39	21	18
45	57	8	49	56	11	45	44	9	35
75	57	7	50	56	24	32	51	12	39
105	33	15	18	52	23	29	60	22	38
135	-	-	-	-	-	-	50	16	34
155	-	-	-	-	-	-	43	16	27
TOTAL	190	51	139	205	81	124	287	96	191
STRATTON:									
15	20	0	20	37	23	14	46	18	28
45	55	3	52	46	7	39	72	12	60
75	44	4	40	51	9	42	79	37	42
105	39	10	29	39	5	34	87	48	39
135	34	17	17	34	7	27	67	42	25
155	27	18	9	36	13	23	61	37	24
TOTAL	219	52	167	243	64	179	412	194	218
WALSH:									
15	8	0	8	3	0	3	0	0	0
45	31	4	27	39	3	36	37	0	37
75	36	4	32	46	10	36	39	5	34
105	52	18	34	47	11	36	56	16	40
135	53	28	25	29	5	24	46	31	15
155	49	51	-2	44	24	20	49	36	13
TOTAL	229	105	124	208	53	155	227	88	139

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 25. Available soil water by soil depth in the CORN phase of the WCSF rotation at Sterling and Stratton and SORGHUM-1 phase of the WSSF rotation at Walsh in 1995.

SITE & DEPTH (cm)	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
STERLING:									
15	57	23	34	37	14	23	48	28	20
45	61	6	55	52	2	50	46	14	32
75	54	25	29	45	4	41	55	11	44
105	47	45	2	39	17	22	60	15	45
135				-	-	-	49	20	29
155				-	-	-	43	11	32
TOTAL	219	99	120	173	37	136	301	99	202
STRATTON:									
15	9	1	8	27	23	4	30	23	7
45	47	2	45	43	5	38	58	1	57
75	35	10	25	51	10	41	67	2	65
105	36	6	30	49	12	37	63	14	49
135	37	13	24	49	18	31	44	36	8
155	31	14	17	44	22	22	42	36	6
TOTAL	195	46	149	263	90	173	304	112	192
WALSH:									
15	10	2	8	8	0	8	2	0	2
45	33	5	28	43	11	32	34	0	34
75	38	6	32	46	12	34	36	6	30
105	41	10	31	45	14	31	42	6	36
135	49	26	23	22	4	18	38	19	19
155	42	19	23	23	23	0	60	54	6
TOTAL	213	68	145	187	64	123	212	85	127

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 26. Available soil water by soil depth in the SORGHUM-2 phase of the WSSF rotation at Walsh in 1995.

SITE & DEPTH (cm)	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
WALSH:									
15	9	0	9	2	0	2	3	0	3
45	28	9	19	36	8	28	32	0	32
75	27	7	20	29	1	28	39	8	31
105	25	19	6	31	11	20	34	8	26
135	37	43	-6	14	6	8	15	0	15
155	34	40	-6	31	27	4	33	25	8
TOTAL	160	118	42	143	53	90	156	41	115

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 27. Available soil water by soil depth in the CORN of the CS rotation at Walsh in l995.

SITE & DEPTH (cm)	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
WALSH:									
15	8	0	8	0	0	0	10	0	10
45	33	7	26	41	0	41	20	0	20
75	31	4	27	33	0	33	39	7	32
105	54	30	24	10	4	6	43	23	20
135	46	38	8	1	0	1	35	29	6
155	40	38	2	4	2	2	43	46	-3
TOTAL	212	117	95	89	6	83	190	105	85

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 28. Available soil water by soil depth in the SUNFLOWER phase of the CS rotation at Walsh in 1995.

SITE & DEPTH (cm)	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
WALSH:									
15	15	0	15	7	0	7	12	0	12
45	34	5	29	25	0	25	27	0	27
75	34	5	29	32	0	32	40	2	38
105	45	21	24	18	3	15	48	13	35
135	27	13	14	19	10	9	50	28	22
155	13	0	13	34	24	10	66	43	23
TOTAL	168	44	124	135	37	98	243	86	157

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 29. Available soil water by soil depth in the FORAGE SORGHUM phase of the WCSF in 1995.

SITE & DEPTH (cm)	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE	PLANTING	HARVEST	CHANGE
	mm/30cm			mm/30cm			mm/30cm		
STERLING:									
15	38	24	14	33	25	8	38	25	13
45	56	10	46	53	18	35	46	17	29
75	40	8	32	55	25	30	60	43	17
105	35	12	23	54	14	40	58	32	26
135	-	-	-	-	-	-	35	14	21
155	-	-	-	-	-	-	33	16	17
TOTAL	169	54	115	195	82	113	270	147	123
STRATTON:									
15	27	6	21	43	23	20	55	33	22
45	47	9	38	46	8	38	75	24	51
75	48	10	38	53	20	33	79	34	45
105	50	19	31	48	17	31	75	43	32
135	52	28	24	48	18	30	50	25	25
155	52	27	25	49	18	31	54	47	7
TOTAL	276	99	177	287	104	183	388	206	182

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.0

Table 30. Available soil water by depth at various dates in GROWING WHEAT before harvest and WHEAT STUBBLE after harvest in the WF rotation at all three sites on summit soils in 1995.

SITE & DEPTH (cm)	DAY 9/07/94 *planting*	5/18/95	6/13/95	6/27/95	7/11/95 *harvest*	8/1O/95
	mm/30cm					
STERLING:						
15	33	40	38	49	45	57
45	18	54	61	49	30	44
75	23	33	42	27	24	24
105	29	24	28	25	28	18
135						
155						
TOTAL	103	151	169	150	127	143
	11/10/94 *planting*	5/16/95	6/13/95	6/28/95	7/12/95 *harvest*	8/09/95
	mm/30cm					
STRATTON:						
15	39	20	26	22	23	33
45	34	43	44	23	20	25
75	29	32	36	20	18	20
105	30	28	36	25	22	24
135	35	31	39	32	30	30
155	34	28	38	31	28	27
TOTAL	201	182	219	153	141	159
	10/04/94 *planting*	5/15/95	6/08/95	6/26/95 *harvest*	7/13/95	8/08/95
	mm/30cm					
WALSH:						
15	31	0	0	0	11	15
45	20	6	3	2	22	24
75	24	0	0	0	1	9
105	34	8	4	1	0	1
135	41	33	27	18	17	19
155	49	38	31	24	24	25
TOTAL	199	85	65	45	75	93

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 31. Available soil water by depth at various dates in GROWING WHEAT before harvest and WHEAT STUBBLE after harvest in the WCF rotation at all three sites on summit soils in 1995.

SITE & DEPTH (cm)	DAY 9/07/94 *planting*	5/18/95	6/13/95	6/27/95	7/11/95 *harvest*	8/10/95
	mm/30cm					
STERLING:						
15	22	33	30	50	36	50
45	10	54	54	52	22	34
75	13	35	47	32	27	20
105	10	25	29	23	25	16
135						
155						
TOTAL	55	147	160	157	110	120
	11/10/94 *planting*	5/16/95	6/13/95	6/28/95	7/12/95 *harvest*	8/09/95
	mm/30cm					
STRATTON:						
15	37	10	3	14	14	30
45	36	52	52	28	24	32
75	30	36	40	22	21	19
105	32	36	43	28	25	24
135	32	31	39	30	29	24
155	29	30	37	23	29	22
TOTAL	196	195	214	145	142	151
	10/04/94 *planting*	5/15/95	6/08/95	6/26/95 *harvest*	7/13/95	8/08/95
	mm/30cm					
WALSH:						
f5	35	0	0	0	5	8
45	34	9	6	5	28	29
75	29	2	1	0	8	17
105	44	15	12	10	9	11
135	39	35	28	23	26	24
155	38	28	22	15	16	18
TOTAL	219	89	69	53	92	107

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 32. Available soil water by depth at various dates in GROWING WHEAT before harvest and WHEAT STUBBLE after harvest in the WCSF rotation at all three sites on summit soils in 1995.

SITE & DEPTH (cm)	DAY 9107/94 *planting*	5/18/95	6/13/95	6/27/95	7/11/95 *harvest*	8/10/95
	mm/30cm					
STERLING:						
15	39	38	32	52	36	54
45	25	59	65	55	15	38
75	19	34	41	30	24	19
105	22	17	24	23	14	16
135						
155						
TOTAL	105	148	162	160	89	127

	11/10/94 *planting*	5/16/95	6/13/95	6/28/95	7/12/95 *harvest*	8/09/95
	mm/30cm					
STRATTON:						
15	47	0	13	21	27	39
45	35	49	49	31	28	36
75	27	32	39	22	20	21
105	31	30	41	26	25	26
135	31	29	39	31	26	31
155	32	30	38	32	31	33
TOTAL	203	170	219	163	157	186

	10/04/94 *planting*	5/15/95	6/08/95	6/26/95 *harvest*	7/13/95	8/08/95
	mm/30cm					
WALSH:						
15	13	17	12	0	6	5
45	10	27	22	7	10	3
75	8	26	23	13	11	5
105	10	28	33	20	20	14
135	14	41	47	40	41	39
155	18	47	46	42	44	46
TOTAL	73	186	183	122	132	112

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 33. Available soil water by depth at various dates in GROWING WHEAT before harvest and WHEAT STUBBLE after harvest in the OPPORTUNITY rotation at all three sites on summit soils 1995.

SITE & DEPTH (cm)	DAY 9/07/94 *planting*	5/18/95	6/13/95	6/27/95	7/11/95 *harvest*	8/10/95
	mm/30cm					
STERLING:						
15		48	42	46	34	45
45		50	56	34	15	15
75		23	24	21	17	20
105		29	28	27	24	23
135				.		
155						
TOTAL	0	150	150	128	90	103

	11/10/94 *planting*	5/16/95	6/13/95	6/28/5	7/12/95 *harvest*	8/09/95
	mm/30cm					
STRATTON:						
15	44	16	24	17	11	20
45	39	53	53	20	13	14
75	30	35	40	22	10	15
105	31	32	36	26	20	19
135	26	28	31	23	18	14
155	28	25	33	25	22	21
TOTAL	198	189	217	133	94	103

	10/04/64 *planting*	5/15/95	6/08/95	6/26/65 *harvest*	7/13/85	8/08165
	mm/30cm					
WALSH:						
15	34	0	0	0	10	15
45	31	8	5	3	25	26
75	46	11	8	5	15	27
105	49	31	25	21	22	25
135	41	39	33	27	35	30
155	43	17	31	24	26	28
TOTAL	244	106	102	80	133	151

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 34. Available soil water by depth at various dates for CORN in the WCF rotation at Sterling and Stratton and SORGHUM in the WSF rotation at Walsh on summit soils in 1995.

SITE & DEPTH (cm)	DAY 5/18/95	7/11/95	8/02/95	8/10/95	9/01/95	10/08/95
	mm/30cm					
STERLING:						
15	43	51	41	35	21	21
45	57	46	42	26	15	8
75	57	48	33	26	10	7
105	33	31	27	26	17	15
135	-					
155	-			-		
TOTAL	190	176	144	113	63	50

	5/16/95	6/28/95	7/12/95	8/01/95	8/09/95	8/31/95	10/11/95
STRATTON:							
15	20	31	37	10	3	0	0
45	55	52	42	17	8	4	3
75	44	51	43	30	21	7	4
105	39	47	43	34	30	17	10
135	34	49	44	38	37	24	17
155	27	47	44	37	34	24	18
TOTAL	218	276	216	165	132	77	53

	6/08/95	8/08/85	8/30/95	9/28/95
	mm/30cm			
WALSH:				
15	8	1	0	0
45	31	12	4	4
75	36	21	3	4
105	52	44	22	18
135	53	54	34	28
155	49	55	36	51
TOTAL	229	187	99	104

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 35. Available soil water by depth at various dates for CORN in the WCSF rotation at Sterling and Stratton and SORGHUM in the WSSF rotation at Walsh on summit soils in 1995.

SITE & DEPTH (cm)	DAY 5/18/95	7/11/95	8/02/95	8/1O/95	9/01/95	10/08/95
	mm/30cm					
STERLING						
15	57	66	47	35	16	23
45	61	40	39	22	7	6
75	54	52	45	43	27	25
105	47	49	53	51	48	45
f35			.			
155						
TOTAL	218	207	184	152	98	99

	5/16/95	6/28/95	7/12/95	8/01/95	8/09/95	8/31/95	10/11/95
	mm/30cm						
STRATTON:							
15	9	33	27	12	5	2	1
45	47	46	26	15	5	3	2
75	35	42	20	23	12	4	10
105	36	47	25	35	26	8	6
135	37	54	26	46	39	23	13
155	31	57	31	46	38	34	14
TOTAL	195	281	131	177	130	73	46

	6/08/95	8/06/95	8/30/95	9/28/95
	mm/3Ccm			
WALSH:				
15	10	10	0	2
45	33	21	6	5
75	36	25	6	6
105	41	36	13	10
135	49	47	32	26
155	42	40	30	19
TOTAL	213	178	66	68

1. To convert from millimeters of H20/30 centimeters of soil to inches of H20/foot of soil multiply by 0.04.

Table 36a . Total Nitrogen and Phosphorus content of WHEAT GRAIN in the 1994-1995 crop.

SITE & ROTATION	SLOPE POSITION: SUMMIT *NP Side** N	SUMMIT *NP Side** P	SUMMIT *NP Side* N	SUMMIT *NP Side* P	SIDESLOPE *NP Side** N	SIDESLOPE *NP Side** P	SIDESLOPE *NP Side* N	SIDESLOPE *NP Side* P	TOESLOPE *NP Side** N	TOESLOPE *NP Side** P	TOESLOPE *NP Side* N	TOESLOPE *NP Side* P
STERLING:	%				%				%			
WF	2.57	0.49	2.44	0.53	2.46	0.44	2.20	0.43	2.43	0.43	2.45	0.46
WCF	2.45	0.48	2.41	0.47	2.27	0.47	2.20	0.47	2.20	0.46	2.18	0.45
WCSF	2.19	0.42	2.26	0.46	2.05	0.40	1.96	0.39	2.12	0.47	2.25	0.46
OPP	2.42	0.47	2.50	0.50	2.41	0.41	2.21	0.43	2.25	0.48	2.35	0.47
	N	P	N	P	N	P	N	P	N	P	N	P
STRATTON:	%				%				%			
WF	2.24	0.42	2.16	0.46	2.38	0.39	2.28	0.41	2.13	0.42	2.52	0.41
WCF	2.40	0.39	2.26	0.40	2.52	0.37	2.42	0.40	2.06	0.45	2.09	0.47
WCSF	2.19	0.46	2.21	0.48	2.35	0.38	2.31	0.44	2.23	0.46	2.13	0.42
OPP	2.36	0.41	2.35	0.40	2.43	0.41	2.40	0.45	2.24	0.44	2.24	0.46
	N	P	N	P	N	P	N	P	N	P	N	P
WALSH:	%				%				%			
WF	2.44	0.36	2.63	0.30								
WSF	2.32	0.33	2.36	0.36								
WSSF	2.44	0.35	2.47	0.39								
OPP	2.39	0.38	2.32	0.38								

* 1st year of receiving phosphorus.

Table 36b. Total Nitrogen and Phosphorus content of WHEAT STRAW in the 1994-1995 crop.

SITE & ROTATION	SLOPE POSITION											
	SUMMIT				SIDESLOPE				TOESLOPE			
	*NP Side**		*NP Side*		*NP Side**		*NP Side*		*NP Side**		*NP Side*	
	N	P	N	P	N	P	N	P	N	P	N	P
STERLING:	%				%				%			
WF	0.38	0.07	0.40	0.07	0.39	0.08	0.34	0.05	0.40	0.07	0.43	0.07
WCF	0.42	0.06	0.34	0.07	0.29	0.03	0.30	0.05	0.35	0.07	0.36	0.09
WCSF	0.31	0.05	0.33	0.07	0.27	0.04	0.28	0.06	0.30	0.05	0.38	0.09
OPP	0.33	0.05	0.30	0.05	0.38	0.04	0.34	0.04	0.31	0.07	0.35	0.07
	N	P	N	P	N	P	N	P	N	P	N	P
STRATTON:	%				%				%			
WF	0.34	0.07	0.35	0.06	0.38	0.03	0.35	0.04	0.61	0.13	0.51	0.09
WCF	0.44	0.04	0.37	0.04	0.38	0.03	0.36	0.04	0.69	0.17	0.61	0.14
WCSF	0.31	0.04	0.31	0.04	0.35	0.03	0.36	0.04	0.59	0.12	0.69	0.15
OPP	0.42	0.05	0.64	0.07	0.36	0.03	0.40	0.04	0.52	0.09	0.50	0.09
	N	P	N	P	N	P	N	P	N	P	N	P
WALSH:	%				%				%			
WE	0.64	0.05	0.65	0.05	0.58	0.04	0.54	0.05	0.58	0.07	0.54	0.06
WSF	0.67	0.05	0.51	0.04	0.59	0.04	0.66	0.05	0.51	0.06	0.49	0.07
WSSF	0.59	0.05	0.57	0.04	0.61	0.05	0.58	0.05	0.52	0.06	0.54	0.07
OPP	0.71	0.05	0.71	0.05	0.66	0.04	0.80	0.06				

* 1st year of receiving phosphorus.

Table 37a. Total Nitrogen and Phosphorus content of CORN & SORGHUM GRAIN in the 1995 crop.

SITE & ROTATION	SLOPE POSITION											
	SUMMIT				SIDESLOPE				TOESLOPE			
	*NP Side**		*NP Side*		*NP Side**		*NP Side*		*NP Side**		*NP Side*	
	N	P	N	P	N	P	N	P	N	P	N	P
STERLING:	%				%				%			
WCF	1.73	0.37	1.70	0.41	1.64	0.29	1.66	0.35	1.48	0.37	1.56	0.38
WCSF	1.83	0.39	1.74	0.41	1.77	0.35	1.62	0.39	1.58	0.42	1.52	0.43
	N	P	N	P	N	P	N	P	N	P	N	P
STRATTON:	%				%				%			
WCF	1.69	0.30	1.68	0.34	1.60	0.35	1.67	0.32	1.59	0.35	1.59	0.42
WCSF	1.64	0.25	1.69	0.33	1.67	0.30	1.63	0.34	1.63	0.39	1.56	0.40
WALSH:	N	P	N	P	N	P	N	P	N	P	N	P
	%				%				%			
WSF	1.80	0.20	1.77	0.16	1.82	0.22	1.78	0.22	1.75	0.23	1.81	0.27
WSSF-1	1.78	0.26	1.79	0.25	1.75	0.16	1.77	0.18	1.70	0.27	1.70	0.27
WSSF-2	1.55	0.17	1.72	0.18	1.55	0.17	1.74	0.21	1.53	0.23	1.70	0.25
CS(Sunflower)	2.90	0.45	2.90	0.45								
CS (Corn)	1.64	0.31	1.51	0.32	1.61	0.32	1.54	0.33	1.53	0.37	1.46	0.40

Table 37b. Total Nitrogen and Phosphorus content of CORN & SORGHUM STOVER in the 1995 crop.

SITE & ROTATION	SLOPE POSITION											
	SUMMIT				SIDESLOPE				TOESLOPE			
	N Side		*NP Side*		*N Side*		*NP Side*		*N Side*		*NP Side*	
	N	P	N	P	N	P	N	P	N	P	N	P
STERLING:	%				%				%			
WCF	0.86	0.04	0.87	0.06	0.72	0.04	0.67	0.05	0.49	0.04	0.51	0.05
WCSF	1.03	0.04	1.11	0.07	0.69	0.03	0.65	0.04	0.63	0.04	0.68	0.06
	N	P	N	P	N	P	N	P	N	P	N	P
STRATTON:	%				%				%			
WCF	0.81	0.03	0.79	0.03	0.79	0.07	0.89	0.05	0.66	0.09	0.72	0.09
WCSF	0.84	0.05	0.89	0.05	0.81	0.04	0.75	0.05	0.83	0.07	0.77	0.09
	N	P	N	P	N	P	N	P	N	P	N	P
WALSH:	%				%				%			
WSF	0.79	0.06	0.82	0.08	0.70	0.06	0.67	0.09	0.59	0.14	0.72	0.17
WSSF-1	0.77	0.08	0.69	0.10	0.62	0.07	0.69	0.06	0.55	0.10	0.61	0.11
WSSF-2	0.77	0.07	0.62	0.06	0.59	0.05	0.72	0.09	0.60	0.13	2.19	0.13
CS(Sunflower)	1.05	0.07	1.08	0.08	1.25	0.09	1.05	0.12	1.02	0.19	0.49	0.18
CS (Corn)	0.70	0.06	0.70	0,06	0.76	0.07	0.43	0.06	0.68	0.09	0.92	0.10

Table 38. Total Nitrogen and Phosphorus content of Forage Sorghum in the 1995 crop.

SITE & ROTATION	SLOPE POSITION											
	SUMMIT				SIDESLOPE				TOESLOPE			
	N Side		*NP Side*		*N Side*		*NP Side*		*N Side*		*NP Side*	
	N	P	N	P	N	P	N	P	N	P	N	P
STERLING:	%				%				%			
WCSF	1.38	0.13	1.45	0.14	1.23	0.15	1.33	0.16	1.00	0.18	1.05	0.17
	N	P	N	P	N	P	N	P	N	P	N	P
STRATTON:	%				%				%			
WCSF	1.00	0.09	0.83	0.13	1.29	0.13	1.23	0.13	1.24	0.18	1.26	0.23

Table 39. Total Nitrogen content of Perennial Grass biomass in 1995.

SITE & ROTATION	SLOPE POSITION: SUMMIT	SIDE	TOESLOPE
	N	N	N
STERLING:	------% --------	------% -------	--------% --------
Grass	0.56	0.46	0.46
	N	N	N
STRATTON:	- - - - - % - - - - -	-------% -------	--------% --------
Grass	0.38	0.43	0.65
	N	N	N
WALSH:	--------% --------	--------% --------	--------% --------
Grass	0.36	0.31	0.53

Table 40. Nitrate-N content of the soil profile at PLANTING for each crop during the 1994-1995 crop year.

SITE & ROTATION	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	Crop & Time			Crop & Time			Crop & Time		
	WHEAT FALL 94	CORN SPR.95	FORAGE SPR.95	WHEAT FALL 94	CORN SPR.95	FORAGE SPR.95	WHEAT FALL 94	CORN SPR.95	FORAGE SPR.95
STERLING:	Kg/ha NO3-N			Kg/ha N03-N			Kg/ha N03-N		
WF	76			84			67		
WCF	51	89		58	69		50	41	
WCSF	52	82	77	34	50	40	46	66	86
OPP	64			55			44		
GRASS			11			7			9
	WHEAT FALL 94	CORN SPR.95	FORAGE SPR.95	WHEAT FALL 94	CORN SPR.95	FORAGE SPR.95	WHEAT FALL 94	CORN SPR.95	FORAGE SPR.95
STRATTON:	Kg/ha N03-N			Kg/ha NO3-N			Kg/ha N03-N		
WF	102			141			107		
WCF	71	28		47	39		60	62	
WCSF	40	19	32	74	33	34	126	73	69
OPP	139			119			139		
GRASS			3			3			3
	WHEAT FALL 93	CORN SORGHUM SPR.94	SUNFLOWER SPR.94	WHEAT FALL 93	CORN SORGHUM SPR.94	SUNFLOWER SPR.94	WHEAT FALL 93	CORN SORGHUM SPR.94	SUNFLOWER SPR.94
WALSH:	Kg/ha NO3-N			Kg/ha N03-N			Kg/ha NO3-N		
WF	90			106			69		
WSF	55	70		59	76		49	81	
W(S)SF	36	49		33	25		36	54	
WS(S)F		43			54			53	
CS (Sunflower)			78			154			76
CS (Corn)		51			54			46	
OPP	127			125			62		
GRASS			11			11			19

1. For conversion to lbs/Acre multiply Kg/ha by 0.893.

APPENDIX I
ANNUAL HERBICIDE PROGRAMS
FOR EACH LOCATION

Table 1. Herbicide rate, cost and date applied at STERLING SITE in 1995 Season.

Rotation Crop	Herbicide	Rate [English]	Rate [Metric]	Weed Pressure	Herbicide Cost	Date Applied
ROTATION: WHEAT-FALLOW						
WHEAT	Banvel	4 oz	.29 l/ha	III	$ 2.56	April 5
	2,4-D Amine 4lb	1/2 pt/Acre	.58 l/ha	III	$ .67	April 5
	X-77	1 qt/100 gal	.2 l/ha	III	$ .44	April 5
	Command 4 EC	1 pt/A	1.17 l/ha	I	$11.31	Sept. 14
	Atrazine 4L	1 pt/A	1.75 l/ha	I	$ 1.56	Sept. 14
	X-77	1 qt/100 gal	.2 l/ha	III	$ .44	Sept. 14
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	August 18
FALLOW	Landmaster BW	54 oz/Acre	3.94 l/ha	I	$ 7.93	June 13
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	July 13
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	August 18
ROTATION: WHEAT-CORN-FALLOW						
WHEAT	Banvel	4 oz	.29 l/ha	III	$ 2.56	April 5
	2,4-D Amine 4lb	1/2 pt/Acm	.56 l/ha	III	$ .67	April 5
	X-77	1 qt/100 gal	.2 l/ha	III	$ .44	April 5
	Landmaster BW	40 oz/Acra	2.9 l/ha	I	$ 5.88	August 18
	Command 4 EC	1.0 Pt/Acre	1.17 l/ha	I	$11.31	Sept. 14
	Atrazine 4L	1.0 Pt/Acre	1.17 l/ha	I	$ 1.58	Sept. 14
	X-77	1 qt/100 gal	.2 l/ha	III	$ .44	Sept. 14
CORN	Accent	.67 oz		I	$17.89	June 13
	Marksman	1 qt/Acre		I	$6.50	June 13
	Penetrate II	1 qt/100 gal	.2 l/ha	I	$ .55	June 13
	Banvel	.5 pt/Acre	.58 l/ha	II	$4.65	July 13
FALLOW	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	June 13
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	August 18
ROTATION: WHEAT-CORN-SUNFLOWER-FALLOW						
WHEAT	Banvel	4 oz	.29 l/ha	III	$ 2.56	April 5
	2,4-D Amine 4lb	1/2 pt/Acre	.58 l/ha	III	$ .67	April 5
	X-77	1 qt/100 gal	.2 l/ha	III	$ .44	April 5
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	August 18
	Command 4 EC	1.0 Pints/A	1.17 l/ha	I	$11.31	Sept. 14
	Atrazine 4L	1.0 Pints/A	1.17 l/ha	I	$ 1.58	Sept. 14
	X-77	1 qt /100 gal	.2 l/ha	III	$ .44	Sept. 14
CORN	Accent	.67 oz	.05 l/ha	I	$18.76	June 13
	Marksman	1 qt/Acre	2.34 l/ha	I	$ 6.28	June 13
	Penetrate II	1 qt/100 gal	.2 l/ha	I	$ .55	June 13
	Banvel	.5 pt/Acre	.58 l//ha	II	$ 4.51	July 13
SUNFLOWER	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	June 13
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	July 13
FALLOW	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	April 5
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	June 13
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	August 18

ROTATION: OPPORTUNITY CROPPING

WHEAT	**Banvel**	**4 oz**	**.29 l/ha**	**III**	**$ 2.56**	**April 5**
	2,4-D Amine 4lb	**1/2 pt/Acre**	**.58 l/ha**	**III**	**$ .67**	**April 5**
	X-77	**1 qt/100 gal**	**.2 l/ha**	**III**	**$ .44**	**April 5**
	Landmaster BW	**40 oz/Acre**				
	Command 4 EC	**1.0 Pints/A**	**1.17 l/ha**	**I**	**$ 11.31**	**Sept. 14**
	Atrazine 4L	**1.0 Pints/A**	**1.17 l/ha**	**I**	**$ 1.58**	**Sept. 14**
	X-77	**1 qt/100 gal**	**.2 l/ha**	**III**	**$ .44**	**Sept. 14**

Weed Pressure Ratings: **I = High Weed pressure -Farmer would need to spray**
II = Medium Weed pressure - Farmer would delay spray application
III = Low Weed pressure -Farmer would not plan a spray application

NOTE: Atrazine and Command herbicides applied at 75 % of the rate on sideslopes.
*** * Cyclone was applied by a shielded sprayer for target grasses within the inter-row.**

Table 2. Herbicide rate, cost and date applied at STRATTON SITE in 1995 Season.

Rotation crop	Herbicide	Rate [English]	Rate [Metric]	Weed Pressure	Herbicide cost	Date Applied
ROTATION: WHEAT-FALLOW						
WHEAT	Banvel	4 oz	.29 l/ha	III	$ 2.56	April 5
	2,4-D Amine 4lb	1/2 pt/Acre	.58 l/ha	III	$ .67	April 5
	X-77	1 qt/1OO gal	.2 l/ha	III	$ .44	April 5
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	Aug. 17
	Command 4 EC	1 pt/A	1.17 l/ha	I	$ 11.31	Sept. 13
	Atrazine 4L	1 pt/A	1.75 l/ha	I	$ 1.58	Sept. 13
	X-77	1 qt/100 gal	.2 l/ha	III	$ .44	Sept. 13
FALLOW	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	July 13
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	Aug. 17
ROTATION: WHEAT-CORN-FALLOW						
WHEAT	Banvel	4 oz	.29 l/ha	III	$ 2.56	April 5
	2,4-D Amine 4lb	1/2 pt/Acre	.58 l/ha	III	$ .67	April 5
	X-77	1 qt/100 gal	.2 l/ha	III	$	April 5
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	Aug. 17
	Command 4 EC	1 pt/A	1.17 l/ha	I	$ 11.31	Sept. 13
	Atrazine 4L	1 pt/A	1.75 l/ha	I	$ 1.58	Sept. 13
	X-77	1 qt/100 gal	.2 l/ha	III	$ .44	Sept. 13
CORN	Prowl	1.0 Qts/Acre	2.34 l/ha	I	$ 6.61	April 5
	Atrazine 4L	1.0 Qts/Acre	2.34 l/ha	I	$ 3.16	April 5
	Banvel	.5 pt/Acre	.58 l/ha	II	$ 5.13	July 13
FALLOW	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	July 13
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	Aug. 17
ROTATION: WHEAT-CORN-SUNFLOWER-FALLOW						
WHEAT	Banvel	4 oz	.29 l/ha	III	$ 2.56	April 5
	2,4-D amine	1/2 pt/Acre	.58 l/ha	III	$ .67	April 5
	X-77	1 qt/100 gal	.2 l/ha	III	$ .44	April 5
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	Aug. 17
	Command 4 EC	1 pt/A	1.17 l/ha	I	$ 11.31	Sept. 13
	Atrazine 4L	1 Pt/A	1.75 l/ha	I	$ 1.58	Sept. 13
	X-77	1 qt/100 gal	.2 l/ha	III	$ .44	Sept. 13
CORN	Prowl	1.0 Qts/Acre	2.34 l/ha	I	$ 6.61	April 5
	Atrazine 4L	1.0 Qt's/Acre	2.34 l/ha	I	$ 3.16	April 5
	Banvei	.5 pt/Acre	.58 l/ha	II	$ 5.13	July 13
SUNFLOWER	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	June 13
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	July 13
FALLOW	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	July 13
	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	Aug. 17

ROTATION: OPPORTUNITY CROPPING

WHEAT	**Banvel**	**4 oz**	**.29 l/ha**	**III**	**$ 2.56**	**April 5**
	2,4-D Amine 4lb	**1/2 pt/Acre**	**.58 l/ha**	**III**	**$ .67**	**April 5**
	X-77	**1 qt/100 gal**	**.2 l/ha**	**III**	**$ .44**	**April 5**
	Landmaster BW	**40 oz/Acre**	**2.9 l/ha**	**I**	**$ 5.88**	**Aug. 17**
	Command 4 EC	**1 pt/A**	**1.17 l/ha**	**I**	**$ 11.31**	**Sept. 13**
	Atrazine 4L	**1 pt/A**	**1.75 l/ha**	**I**	**$ 1.58**	**Sept. 13**
	X-77	**1 qt/100 gal**	**.2 l/ha**	**III**	**$ .44**	**Sept. 13**

Weed Pressure Ratings:

I = High Weed pressure - Farmer would need to spray
II = Medium Weed pressure - Farmer would delay spray application
III = Low Weed pressure - Farmer would not plan a spray application

NOTE: Atrazine and Command herbicides applied at 75 % of the rate on sideslopes.

Table 3. Herbicide rate, cost and date applied at WALSH SITE in 1995 Season.

Rotation Crop	Herbicide	Rate [English]	Rate [Metric]	Weed Pressure	Herbicide Cost	Date Applied
ROTATION: WHEAT FALLOW						
WHEAT	Ally	1/10 oz/Acre	7 g/ha	III	$ 2.80	March 23
	X-77	1 qt/100 gal	.2 l/ha	III	$ .44	March 23
	Landmaster BW	54 oz/Acre	3.94 l/ha	I	$ 7.93	July 28
	Roundup	16 oz/Acre	1.17 LI/ha	I	$ 4.85	August 30
	Activator 90	8 oz/Acre	.6 l/ha	I	$ .55	August 30
	Command EC	16 oz/Acre	1.17 LI/ ha	I	$11.31	August 30
	Atrazine 4L	8 oz/Acre	.6 l/ha	I	$ .79	August 30
FALLOW	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	March 31
	Roundup	16 oz/Acre	1.17 LI/ha	I	$ 4.85	April 7
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	April 7
	Roundup	16 oz/Acre	1.17 LI/ ha	I	$ 4.85	June 12
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	June 12
	Landmaster BW	54 oz/Acre	3.94 l/ha	I	$ 7.93	July 28
	Roundup	16 oz/Acre	1.17 LI/ha	I	$ 4.85	August 30
	Activator 90	8 oz/Acre	.6 l/ha	I	$ .55	August 30
ROTATION: WHEAT-SORGHUM-FALLOW						
WHEAT	Ally	1/10 oz/Acre	7 g/Acre	III	$ 2.80	March 23
	X-77	1 Qt/100 gal	.2 l/ha		$ .44	March 23
	Landmaster BW	54 oz/Acre	3.94 l/ha	I	$ 7.93	July 28
	Roundup	16 oz/Acre	1.17 LI/ha	I	$ 4.85	August 30
	Activator 90	8 oz/Acre	.6 l/ha	I	$ .55	August 30
	Atrazine 4L	8oz/Acre	.6 l/ha	I	$ .79	August 30
SORGHUM	Roundup	16 oz/Acre	1.17 LI/ha	I	$ 4.85	April 7
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	April 7
	Roundup	16 oz/Acre	1.17 LI/ha	I	$ 4.85	May 19
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	May 19
	Roundup	16 oz/Acre	1.17 LI/ha	I	$ 4.85	June 12
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	June 12
	Milopro	9.6 oz/Acre	.7 l/ha	I	$ 2.37	June 12
	Banvel	4 oz/Acre	.29 l/ha	I	$ 2.56	July 28
	2,4-D Amine 4lb	4 oz/Acre	.29 l/ha	I	$ .67	July 28
	Activator 90	6 oz/Acre	.44 l/ha	I	$ .55	July 28
**	Cyclone	1.25 pts/Acre	1.46 l/ha	II	$ 5.56	August 2
	Crop Oil	32 oz/Acre	2.34 l/ha	II	$ 1.20	August 2
	Activator 90	8 oz/Acre	.6 l/ha	II	$ .55	August 2
FALLOW	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	March 31
	Roundup	16 oz/Acre	1.17 LI/ha	I	$ 4.85	June 12
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	June 12
	Landmaster BW	54 oz/Acre	3.94 l/ha	I	$ 7.93	July 28
	Roundup	16 oz/Acre	1.17 LI/ ha	I	$ 4.85	August 30
	Activator 90	8 oz/Acre	.6 l/ha	I	$ .55	August 30

ROTATION: WHEAT-SORGHUM-SORGHUM2-FALLOW

WHEAT	Ally	1/10 oz/Acre	7 g/Acre	III	$ 2.80	March 23
	X-77	1 qt/100 gal	.2 l/ha		$, .44	March 23
	Landmaster BW	54 oz/Acre	3.84 l/ha	I	$ 7.93	July 28
	Roundup	16 oz/Acre	1.17 Ll/ha	I	$ 4.85	August 30
	Activator 90	8 oz/Acre	.6 l/ha	I	$ .55	August 30
	Atrazine 4L	8 oz/Acre	.6 l/ha	I	$ .79	August 30
SORGHUM	Roundup	16 oz/Acre	1.17 Ll/ha	I	$ 4.85	April 7
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	April 7
	Roundup	16 oz/Acre	1.17 Ll/ha	I	$ 4.85	May 19
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	May 19
	Roundup	16 oz/Acre	1.17 Ll/ha	I	$ 4.85	June 12
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	June 12
	Milopro	9.6 oz/Acre	.7 l/ha	I	$ 2.37	June 12
	Banvel	4 oz/Acre	.29 l/ha	I	$ 2.56	July 28
	2,4-D Amine 4lb	4 oz/Acre	.29 l/ha	I	$ .34	July 28
	Activator 90	6 oz/Acre	.44 l/ha	I	$ .55	July 28
	** Cyclone	1.25 pts/Acre	1.46 l/ha	II	$ 5.56	August 2
	Crop Oil	32 oz/Acre	2.34 l/ha	II	$ 1.20	August 2
	Activator 90	8 oz/Acre	.6 l/ha	II	$ .55	August 2
SORGHUM2	Roundup	16 oz/Acre	1.17 Ll/ha	I	$ 4.85	May 19
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	May 19
	Roundup	16 oz/Acre	1.17 Ll/ha	I	$ 4.85	June 12
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	June 12
	Milopro	9.6 oz/Acre	.7 l/ha	I		June 12
	Banvel	4 oz/Acre	.29 l/ha	I	$ 2.56	July 28
	2,4-D Amine 4lb	4 oz/Acre	.29 l/ha	I	$ .34	July 28
	Activator 90	6 oz/Acre	.44 l/ha	I	$ .55	July 28
	** Cyclone	1.25 pts/Acre	1.46 l/ha	II	$ 5.66	August 2
	crop oil	32 oz/Acre	2.34 l/ha	II	$ 1.20	August 2
	Activator 90	8 oz/Acre	.6 l/ha	II	$ .55	August 2
FALLOW	Landmaster BW	40 oz/Acre	2.9 l/ha	I	$ 5.88	March 31
	Roundup	16 oz/Acre	1.17 Ll/ha	I	$ 4.85	June 12
	Activator 90	4 oz/Acre	.3 l/ha	I	$ .55	June 12
	Landmaster BW	54 oz/Acre	3.84 l/ha	I	$ 7.93	July 28
	Roundup	16 oz/Acre	1.17 Ll/ha	I	$ 4.85	August 30
	Activator 90	8 oz/Acre	.6 l/ha	I	$ .55	August 30

ROTATION: CONTINUOUS ROW CROPS						
CORN	**Roundup**	**12 oz/Acre**	**.88 l/ha**	**I**	**$ 3.64**	**May 11**
	Roundup	**16 oz/Acre**	**1.17 l/ha**	**I**	**$ 4.85**	**May 19**
	Activator 90	**4 oz/Acre**	**.3 l/ha**	**I**	**$ .55**	**May 19**
	Exceed	**.88 oz/Acre**	**.06 l/ha**	**I**	**$10.03**	**June 23**
	Accent	**.33 oz/Acre**	**.02 l/ha**	**I**	**$ 9.24**	**June 23**
	Crop Oil	**16 oz/Acre**	**1.17 l/ha**	**I**	**$ .60**	**June 23**
SUNFLOWER	**Treflan**	**20 oz/Acre**	**1.46 l/ha**	**I**	**$ 5.47**	**May 11**
	Roundup	**16 oz/Acre**	**1.17 l/ha**	**I**	**$ 4.85**	**May 19**
	Activator 90	**4 oz/Acre**	**.3 l/ha**	**I**	**$ .55**	**May 19**
	Poast	**20 oz/Acre**	**1.46 l/ha**	**I**	**$ 7.56**	**June23**
	Crop Oil	**32 oz/Acre**	**2.34 l/ha**	**I**	**$ 1.20**	**June 23**
ROTATION: OPPORTUNITY CROPPING						
WHEAT	**Ally**	**1/10 oz/Acre**	**7 g/Acre**	**III**	**$ 2.80**	**March 23**
	X-77	**1 qt/100 gal**	**.2 l/ha**		**$ .44**	**March 23**
	Landmaster BW	**54 oz/Acre**	**3.84 l/ha**	**I**	**$ 7.93**	**July 28**
	Roundup	**16 oz/Acre**	**1.17 Ll/ha**	**I**	**$ 4.85**	**August 30**
	Activator 90	**8 oz/Acre**	**.6 l/ha**	**I**	**$ .55**	**August 30**
	Atrazine 4L	**8 oz/Acre**	**.6 l/ha**	**I**	**$ .79**	**August 30**

Weed Pressure Ratings:

I = High Weed pressure - Farmer would need to spray

II = Medium Weed pressure - Farmer would delay spray application

iii = Low Weed pressure - Farmer would not plan a spray application

*** * Cyclone was applied by a shielded sprayer for target grasses within the inter-row.**

APPENDIX II
PROJECT PUBLICATIONS

Papers in Scientific Journals:

Kitchen, N. R., L. A. Sherrod, C. W. Wood, G. A. Peterson and D. G. Westfall. 1990. Nitrogen contamination of soils from sampling bags. Agron. J. 82:354-356.

Kitchen, N. R., J. L. Havlin and D. G. Westfall. 1990. Soil sampling under no-till banded phosphorus. Soil Sci. Soc. Am. J. 54:1661-1665.

Wood, C. W., D. G. Westfall, G. A. Peterson and I. C. Burke. 1990. Impacts of cropping intensity on carbon and nitrogen mineralization under no-till agroecosystems. Agron. J. 82:1115-1120.

Wood, C. W., D. G. Westfall and G. A. Peterson. 1991. Soil carbon and nitrogen changes upon initiation of no-till cropping systems in the West Central Great Plains. Soil Sci. Sot. Am. J. 55:470-476.

Wood, C. W., G. A. Peterson, D. G. Westfall, C. V. Cole and W. F. Willis. 1991. Nitrogen balance and biomass production of newly established no-till dryland agroecosystems. Agron. J. 83:519-526.

Moore, I. D., P.E. Gessler, G.A. Nielsen, and G.A. Peterson. 1993. Soil attribute prediction using terrain analysis. Soil Sci. Sot. Am. J. 57:443-452.

Peterson, G.A., D.G. Westfall, and C.V. Cole. 1993. Agroecosystem approach to soil and crop management research. Soil Sci. Soc. Am. J. 57:1354-1360.

Evans, S.D., G.A. Peterson, D.G. Westfall and E. McGee. 1994. Nitrate leaching in dryland agroecosystems as influenced by soil and climate gradients. J. Environ. Qual. 23:999-1005.

Rodriguez, J.B., J.R. Self, G.A. Peterson, and D.G. Westfall. 1995. Comparison of extractable phosphorus from two sulfuric acid methods with the Mehlich phosphorus test number one. Commun. Soil Sci. Plant Anal. 26:3165-3173.

Chapters in Books or Monographs:

Peterson, G.A. 1994. Interactions of surface residues with soil and climate. p. 9-12. IN: W.C. Moldenhauer and A.L. Black (eds.) Crop residue management to reduce erosion and improve soil quality: Northern Great Plains. USDA/ARS Cons. Res. Report No. 38. Washington, D.C.

Westfall, D. G., W.R. Raun, J.L. Havlin, G.V. Johnson, J.E. Matocha, and F.M. Hons. 1994. Fertilizer management. p. 33-36. IN: B.A. Stewart and W.C. Moldenhauer (eds.) Crop residue management to reduce erosion and improve soil quality: Southern Great Plains. USDA/ARS Cons. Res. Report No. 37. Washington, D.C.

Publications in Proceedings:

Peterson, G. A. and D. G. Westfall. 1987. Integrated research in soil and crop management.p. 3-5. IN: Proc. Western Phosphate Conf. March 1987. Corvallis, OR.

Kitchen, N. R. , D. G. Westfall and G. A. Peterson. 1988. Nitrogen fertilizer use efficiency in dryland no-till crop rotations. p. 172-179. IN: 1988 Symposium Proc. Fluid Fertilizer Research as a Basis for Efficient Crop Production. March 15-17, 1988.

Wood, C. W., D. G. Westfall and J. M. Ward. 1988. Phosphorus placement in dryland winter wheat. IN: Proc. Great Plains Soil Fert. Workshop 2:79-83.

Peterson, G. A., D. G. Westfall and W. O. Willis. 1988. Systems research: a necessity for the future of agronomic research. p. 739-740. IN: Proc. Int. Conf. Dryland Farming, Aug. 15-19, 1988. Amarillo, TX.

Kitchen, N. R., D. G. Westfal1 and G. A. Peterson. 1988. Nitrogen fertilizer use efficiency in dryland no-till crop rotations. p. 223-229. IN: Proc. Fluid Fert. Found. Symp., March, 1988, Scottsdale, AZ.

Westfall, D. G. and G. A. Peterson. 1989. Long-term dryland cropping systems research for the Central Great Plains. p. 1. IN: Proc. Western Soc. Soil Sci. Bozeman, MT, June 20-22, 1989.

Peterson, G. A. and D. G. Westfall. 1990. Long-term soil-crop management research for the 21st century. p. 132-136. IN: Proc. Great Plains Soil Fert. Conf., Denver, CO, March 6-7, 1990.

Kitchen, N. R., D. G. Westfall, G. A. Peterson and J. L. Havlin. 1990. Soil sampling under no-till banded phosphorus fertilizer. p. 159-164. IN: Proc. Great Plains Soil Fert. Conf., Denver, CO, March 6-7, 1990.

Kitchen, N. R., D. G. Westfall and G. A. Peterson. 1990. Fertilizer use efficiency in dryland no-till crop rotations. p. 218-227. IN: Proc. Fluid Fert. Found., Scottsdale, AZ, March 13-15, 1990.

Peterson, G. A. and D. G. Westfall. 1990. Dryland cropping systems to enhance water quality. p. 93-104. IN: Proc. Non-point Water Quality Symp., Colorado Springs, CO, March 22-23, 1990.

Westfall, D. G. and G. A. Peterson. 1990. Nitrogen efficiency in dryland agroecosystems. p. 155-163. IN: Proc. Great Plains Conserv. Tillage Symp. Great Plains Agricultural Council Bulletin No. 131. Bismarck, ND, August 21-23, 1990.

Peterson, G. A. and D. G. Westfall. 1990. Sustainable dryland agroecosystems. p. 23-29. IN: Proc. Great Plains Conserv. Tillage Symp. Great Plains Agricultural Council Bulletin No. 131. Bismarck, ND, Aug. 21-23, 1990.

Peterson, G.A. 1991. Soil and crop management as a driving variable. p. 255. IN: J.D. Hanson, M.J. Shaffer, D.A. Ball and C.V. Cole (eds.), Sustainable Agriculture for the Great Plains, Symposium Proceedings. USDA-ARS, ARS-89.

Westfall, D.G. and G.A. Peterson. 1991. Optimum production and nitrogen fertilizer use in dryland no-till crop rotations. p.48. IN: Proc. Pacific Div. AAAS, June 23-27, 1991, Logan, UT.

Westfall, D. G., R-L. Kolberg, N.R. Kitchen, and G.A. Peterson. 1991. Nitrogen fertilizer use efficiency in dryland no-till crop rotations. p. 260-270. IN: Proc. Fluid Fert. Found. Symp., March 1991, Scottsdale, AZ.

Peterson, G.A., D.G. Westfall, and A.D. Halvorson. 1992. Economics of dryland crop rotations for efficient water and nitrogen use. p. 47-53. IN: Proc. Great Plains Soil Fert. Conf., Denver, CO, March 3-4, 1992.

Westfall, D. G., R.L. Kolberg, and G.A. Peterson. 1992. Nitrogen fertilizer use efficiency in dryland no-till crop rotations. p. 244-257. IN: Proc. Fluid Fert. Found. Symp., March 1992, Scottsdale, AZ.

Peterson, G.A., and C.V. Cole. 1993. Productivity of Great Plains soils: Past, present and future. IN: Proceedings of the Great Plains Ecosystems Symposium. Kansas City, MO. 7-9 April 1993.

Moore, I.D., P-E. Gessler, G.A. Nielsen, and G.A. Peterson. 1993. Soil attribute prediction using terrain analysis. p. 27-55. IN: Robert, P. C., et al. (eds.) Proc. of Workshop: Soil Specific Crop Management. Minneapolis, MN. 14-16 April 1992. Am. Soc. of Agron. Madison, WI.

Westfall, D. G., R.L. Kolberg, and G.A. Peterson. 1993. Nitrogen fertilizer use efficiency in dryland no-till crop rotations. p. 153-163. IN: Proc. Fluid Fert. Found. Symp. March 1993. Scottsdale, AZ.

Westfall, D. G., G.A. Peterson, and R.L. Kolberg. 1994. Fluid systems for dryland agriculture. p. 129-134. IN: Proc. Fluid Fert. Found. Syrnp. "Research for Tomorrow" February 1994. Scottsdale, AZ.

Westfall, D. G., R.L. Kolberg, and G.A. Peterson. 1994. Nitrogen management for intensified dryland agroecosystems. p. 12-17. IN: Proc. Great Plains Soil Fertility Conference. 7-9 March 1994. Denver, CO.

Peterson, G.A., D.G. Westfall, N.E. Toman, and R. E. Anderson. 1994. Sustainable dryland cropping systems: Economic analysls. p. 30-35. IN: Proc. Great Plains Soil Fertility Conference. 7-9 March 1994. Denver, CO.

Rouppet, B., R.L. Kolberg, R.L. Waskom, D.G. Westfall, and G.A. Peterson. 1994. In-situ soil nitrogen mineralization methodology. p. 30-35. IN: Proc. Great Plains Soil Fertility Conference. 7-9 March 1994. Denver, CO.

Peterson, G.A. and D.G. Westfall. 1994. Intensified cropping systems: The key to environmental and economic sustainability in the Great Plains. p. 73-84. IN: Proc. Intensive Wheat Management Conference. 10-11 March 1994. Denver, CO.

Peterson, G.A. and D.G. Westfall. 1994. Economic and environmental impact of intensive cropping systems - Semiarid region. p. 145-158. IN: Proc. Nutrient Management on Highly Productive Soils Conference. 16-18 May 1994. Atlanta, GA.

Westfall, D. G., G.A. Peterson, and R.L. Kolberg. 1994. Nitrogen and phosphorus management of dryland cropping systems. p. 35-41. IN: Proc. Great Plains Residue Management Conference. GPAC Bull. No. 150.15-17 August 1994. Amarillo, TX.

Peterson, G.A., D.G. Westfall, and L. Ahuja. 1995. Sustainable dryland agroecosystems for the Great Plains. IN: Proc. Planning for a Sustainable Future: The case of the North American Great Plains Symposium. 8-10 May 1995. Lincoln, NE.

Peterson, G. A., D.G. Westfal1, and R.L. Kolberg. 1995. Fertilidad en trigo y otros cultivos en areas secas. p. 119-130. IN: Fertilidad de Suelos, Fertilizacion y Siembra Directa. III Jornadas Regionales Symposium. September 1995. Sierra la Ventana Argentina.

Westfall, D. G., G.A. Peterson, and R.L. Kolberg. 1995. Fluid systems for dryland agriculture. p. 127-140. IN: 1995 Fluid Forum Proc. Sponsored by Fluid Fertilizer Foundation. February 1995, Scottsdale, AZ.

Westfall, D. G., G.A. Peterson, and R.L. Kolberg. 1995. Sustainable dryland cropping systems. IN: Proc. Western Nutrient Management Conf. 1:101-105.9-10 March 1995. Salt Lake City, UT.

Technical bulletins or other reports:

Peterson, G. A., D. G. Westfall, W. Wood and S. Ross. 1988. Crop and soil management in dryland agroecosystems. Tech. Bull. LTB88-6. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D. G. Westfall, C. W. Wood, L. Sherrod and E. McGee. 1989. Crop and soil management in dryland agroecosystems. Tech. Bull. TB89-3. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D. G. Westfall, C. W. Wood, L. Sherrod and E. McGee. 1990. Crop and soil management in dryland agroecosystems. Tech. Bull. TB90-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D. G. Westfall, L. Sherrod, E. McGee and R. Kolberg. 1991. Crop and soil management in dryland agroecosystems. Tech. Bull. TB91-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, E. McGee and R. Kolberg. 1992. Crop and soil management in dryland agroecosystems. Tech. Bul.TB92-2. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Croissant, R. L., G.A. Peterson, and D.G. Westfall. 1992. Dryland cropping systems in eastern Colorado. Service in Action No. 516. Cooperative Extension. Colo. State Univ. Fort Collins, CO.

Peterson, G.A., D.G. Westfall, N.E. Toman, and R.L. Anderson. 1993. Sustainable dryland cropping systems: Economic analysis. Tech. Bul. TB93-3. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and B. Rouppet. 1993. Sustainable dryland agroecosystem management. Tech. Bul. TB93-4. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Kolberg, R. L., D.G. Westfall, G.A. Peterson, N.R. Kitchen, and L. Sherrod. 1993. Nitrogen fertilization of dryland cropping systems. Tech. Bul. TB95-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D.G. Westfall, L. Sherrod, R. Kolberg, and B. Rouppet. 1994. Sustainable dryland agroecosystem management. Tech. Bul. TB94-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D.G. Westfall, L. Sherrod, R. Kolberg, and D. Poss. 1995. Sustainable dryland agroecosystem management. Tech. Bul. TB95-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Published Abstracts:

Peterson, G. A. and D. G. Westfall. 1987. Integrated research: a necessity for the future of soil and crop management. Agron. Abstracts p. 213. Amer. Soc. of Agron., Madison, WI.

Peterson, G. A., C. W. Wood and D. G. Westfall. 1988. Building a crop residue base in no-till cropping systems. Agron. Abstracts p. 246. Amer. Sot. of Agron., Madison, WI.

Kitchen, N. R., D. G. Westfall and G. A. Peterson. 1989. Potential N and C mineralization in dryland no-till cropping soils as influenced by N fertilization management. Agron. Abstracts p. 244. Amer. Soc. of Agron., Madison, WI.

Peterson, G. A., D. G. Westfall. 1989. Long-term soil-crop management research for the 21st century. Agron. Abstracts p. 249. Amer. Soc. of Agron., Madison, WI.

Westfall, D. G., N. R. Kitchen and J. L. Havlin. 1989. Soil sampling procedures under no-till banded phosphorus fertility. Agron. Abstracts p. 256. Amer. Soc. of Agron., Madison, WI.

Wood, C. W., G. A. Peterson and D. G. Westfall. 1989. Potential C and N mineralization in dryland agroecosystems as affected by landscape position and crop rotation. Agron. Abstracts p. 256. Amer. Soc. of Agron., Madison, WI.

Follett, R. H., G. A. Peterson, C. W. Wood and D. G. Westfall. 1989 Developing a crop residue base to decrease erosion potential. Abstract of the Annual Meeting of the Soil and Water Conservation Society. 30 July 1989. Edmonton, Canada.

Kitchen, N. R., D. G. Westfall and G. A. Peterson. 1990. Nitrogen fertilization management in no-till dryland cropping systems. Agron. Abstracts p. 272. Amer. Soc. of Agron., Madison, WI.

Peterson, G. A., C. W. Wood and D. G. Westfall. 1990. Cumulative biomass production and N utilization in no-till dryland agroecosystems. Agron. Abstracts p. 322. Amer. Soc. of Agron., Madison, WI.

Wood, C. W., D. G. Westfall and G. A. Peterson. 1990. Impact of cropping intensity under no-till on soil C and N. Agron. Abstracts. p. 328. Amer. Soc. of Agron., Madison, WI.

Evans, S.D., G.A. Peterson, D.G. Westfall, and E-A. McGee. 1991. Nitrate leaching in dryland agroecosystems as influenced by soil and climate gradients. Agron. Abstracts. p.330. Amer. Soc. of Agron., Madison, WI.

McGee, E.A., G.A. Peterson, and D.G. Westfall. 1991. Water-use efficiency of dryland no-till cropping systems in the west central Great Plains. Agron. Abstracts. p.336. Amer. Soc. of Agron., Madison, WI.

McMaster, G. S., J.A. Morgan, and G.A. Peterson. 1991. Wheat yield components for different cropping systems, climates, and catenas.
Agron. Abstracts. p. 153. Amer. Soc. of Agron., Madison, WI.

Peterson, G. A., D.G. Westfall, and E.A. McGee. 1992. Increasing productivity and sustainability of dryland agroecosystems. Abstracts of the First International Crop Science Congress. 14-22 July, 1992. Ames, Iowa. Crop Science Society of America. Madison, WI.

Westfall, D. G., and G.A. Peterson. 1992. Sustainable dryland agroecosystems. Agron. Abstracts. p. 86. Amer. Soc. of Agron., Madison, WI.

McGee, E. A., G.A. Peterson, and D.G. Westfall. 1992. Water-use efficiency as affected by cropping intensity, slope, and evaporate gradient in no-till dryland agroecosystems. Agron. Abstracts. p. 331. Amer. Soc. of Agron., Madison, WI.

Iremonger, C. J., D.G. Westfall, and G.A. Peterson. 1992. Fertilizer phosphorus and cropping intensity effects on P availability. p. 86-92. IN: Proc. Western Phosphorus/Sulfur Workshop. Aug. 6-8, 1992. Anchorage, AK.

Peterson, G.A., D. G. Westfall, N.E. Toman, and R. L. Anderson. 1993. Sustainable dryland cropping systems: Economic analysis. Agron. Abstracts p. 325. Amer. Soc. of Agron., Madison, WI.

Kolberg, R.L., B. Rouppet, D.G. Westfall, and G.A. Peterson. 1993. In situ soil nitrogen mineralization methodology. Agron. Abstracts p. 276. Amer. Soc. of Agron., Madison, WI.

Halvorson, A.D., G.A. Peterson, and S.E. Hinkle. 1993. Tillage and cropping system effects on dryland wheat and corn production. Agron. Abstracts p. 316. Amer. Soc. of Agron., Madison, WI.

Mrabet, R., A. Bouzza, and G.A. Peterson. 1993. Potential reduction in soil erosion in Morocco using no-till systems. Agron. Abstracts p. 323. Amer. Soc. of Agron., Madison, WI.

Rouppet, B., D.G. Westfall, and G.A. Peterson. 1994. In-situ nitrogen mineralization in no-till dryland agroecosystems. Agron. Abstracts p. 316. Amer. Soc. of Agron., Madison, WI.

Peterson, G.A., A.J. Schlegel, D.L. Tanaka and O.R. Jones. 1994. Precipitation use efficiency as related to cropping systems and tillage. Agron. Abstracts p. 356. Amer. Soc. of Agron., Madison, WI.

Ortega, R.A., G.A. Peterson, and D.G. Westfal1. 1994. Net nitrogen mineralization as affected by cropping systems and residue production. Agron. Abstracts p. 372. Amer. Soc. of Agron., Madison, WI.

Peterson, G. A., D.G. Westfall, N.E. Toman and R.L. Anderson. 1994. Sustainable dryland cropping systems on the Colorado High Plains: Economic analysis. AAAS-WSSA Meeting Abstract. 20-23 April 1994.

Sherrod, L., G.A. Peterson, D.G. Westfall, and R.L. Kolberg. 1995. Carbon and nitrogen dynamics as affected by rotation intensity in the Great Plains. Agron. Abstracts p. 25. Amer. Sot. of Agron., Madison, WI.

Peterson, G.A., A.L. Black, A.D. Halvorson, J.L. Havlin, O.R. Jones, and D.J. Lyon. 1995. North American agricultural soil organic matter network: The American Great Plains. Agron. Abstracts p. 25. Amer. Sot. of Agron., Madison, WI.

Ortega, R.A., G.A. Peterson, and D.G. Westfall. 1995. Phosphorus test calibration using spatial variability of a landscape in eastern Colorado. Agron. Abstracts p. 268. Amer. Sot. of Agron., Madison, WI.

Rodriguez, J.B., J.R. Self, G.A. Peterson, and D.G. Westfall. 1995. Sodium bicarbonate-DTPA test for macro and micro nutrients in soils. Agron. Abstracts p. 317. Amer. Sot. of Agron., Madison, WI.

Farahani, H. J., L.A. Ahuja, G. W. Buchleiter, and G.A. Peterson. 1995. Mathematical modeling of irrigated and dryland corn production in eastern Colorado. Abstract for Clean Water-Clean Environment-21st Century Symposium. March 1995. Kansas City, MO.

Farahani, H.J., L.A. Ahuja, G.A. Peterson, R. Mrabet, and L. Sherrod. 1995. Root zone water quality model evaluation of dryland/no-till crop production m eastern Colorado. Abstract of International Symposium on Water Quality Modeling. April 1995. Kissimmee, FL.

Peterson, G.A. and D.G. Westfall. 1995. Post-CRP land use-alternative systems. Abstract of Symposium on Converting CRP-Land to Cropland and Grazing: Conservation Technologies of the Transition. Sponsored by Soil and Water Cons. Sot. of Amer. 6-8 June 1995. Lincoln, NE.

Non-technical papers:

Westfall, D.G. and G. A. Peterson. 1990. Improving your dryland performance. Solutions 34(5):32-34 and 49.

Wood, C. W., G. A. Peterson and D. G. Westfall. 1990. Greater crop management intensity increases soil quality. Better Crops 74(3):20-22.

Westfall, D. G., G.A. Peterson, and J.L. Sanders. 1992. Phosphorus reduces stress in intensive dryland no-till crop rotations. Better Crops with Plant Food. Vol. 76. Fall 1992. pp. 20-21.

Westfall, D. G., G.A. Peterson, R.L. Kolberg, and L. Sherrod. 1994. Extra crop is payoff in dryland no-till intensified cropping system. Fluid Journal 2:18-20.